ELECTRICAL REVIEW

AN ILLUSTRATED WEEKLY JOURNAL OF SCIENTIFIC AND ELECTRICAL PROGRESS.

VOL. 35. No. 6. WEEKLY. NEW YORK, WEDNESDAY, AUGUST 9, 1899. $3 PER ANNUM. SINGLE COPIES, 10 CENTS.

Copyright, 1899, by ELECTRICAL REVIEW PUBLISHING COMPANY, Times Building, 41 Park Row, New York Entered at the Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS

A business house of Aberdeen, Scotland, recently engaged as office boy a raw country youth. It was part of his duties to attend to the telephone in his master's absence. When first called upon to answer the bell, in reply to the usual query: "Are you there?" he nodded assent. Again the question came, and still again, and each time the boy gave an answering nod. When the question came for the fourth time, however, the boy losing his temper, roared through the telephone: "Man, are ye blin'? I've been noddin' me heid aff for t' last hauf 'oor!"

There are now three grades of motormen employed by the Brooklyn, N. Y., Rapid Transit Company, and their pay is as follows: Motormen of surface cars, $2 a day; motormen of bridge trains, $2.25, and motormen of the elevated trains, $2.50. Before the introduction of electricity on the "L" road the latter were locomotive engineers at $3 50 a day.

"The days of the underground cast and wrought-iron gas, water and steam-pipes are about numbered," a Boston electrician is quoted as saying. "Electrolysis is playing high jinks with the iron pipes in all the big cities, and in a few years from now the water-pipes will become so weak that they will burst every time any pressure is put on them on account of being corroded by the action of the powerful currents. I will venture the prediction that seven years from now nothing will be used for underground piping of all kinds where high pressures are carried except glass."

Among the cars consumed in the fire at the South Orange avenue car-barn of the North Jersey Traction Company in Newark, N. J., on August 2, were two of the finest private trolley cars ever built. The "New Jersey" was particularly fine in its lighting and gilt trimmings. The other car, "Judge Krueger," was a solid comfort vehicle, and was provided with an icebox and buffet bar; consequently, it was a favorite with the men who were privileged to use it. Five snow-sweepers were burned also, and they were worth $2,000 each. Seven new cars for the Orange & Passaic Valley line, stored in the barn, were destroyed, together with 62 other cars. The loss has been estimated at $140,000.

Andrew Carnegie has offered, from Scotland, to give $50,000 towards a public library building at Steubenville, Pa., if the citizens will furnish a site and maintain it. Mr. Carnegie in his letter refers to his early days when a telegraph operator in Steubenville. His generous offer will be accepted.

A copper deposit has been discovered in Shasta County, Cal., which promises to rival the Mountain copper mine. The find was made by Rufus H. Herron, of Los Angeles, while prospecting for oil. Three veins of ore, running 30 per cent copper, have so far been located and prospecting has only begun. Experts say the rock will easily run $80 in copper.

FIG. 1.—"BUILDING THE NIAGARA GORGE RAILWAY"—ROAD AROUND THE CLIFF NEAR PLATEAU.

BUILDING THE NIAGARA GORGE RAILWAY.

READ BEFORE THE ENGINEERS CLUB, OF PHILADELPHIA, BY GEORGE A. RICKER.

Benjamin Fenton and Ensign Bennett probably first entertained the idea of constructing a railroad in the Niagara Gorge and organized a company to build a line from the "Maid of the Mist" landing in Prospect Park to the Whirlpool, to be operated by steam, the track to have a gauge of 30 inches. Failing in the effort to purchase right-of-way, the Niagara Falls & Whirlpool Company instituted condemnation proceedings, but the Court of Appeals decided that it was not a railroad "organized for a public use within the meaning of the statute;" that it did not "meet the requirements of the railroad law;" it did not "connect with other lines;" "it was not a common carrier, but was merely a private line for sight-seeing purposes," and therefore could not be permitted to exercise the right of eminent domain.

According to the old notebooks, surveys were begun by Mr. J. E. Shields, the engineer in charge, on March 29, 1886, and show a daily progress of only a few hundred feet, indicating the difficulties and dangers encountered. The appearance of the slope at the water's edge, as seen from the top of the high bank, gives no adequate notion of the tangled character of the vegetation below and the insecure footing over which, for a great part of the distance, it was necessary to scramble on all fours, and the balance of the line presenting almost vertical cliffs frowning over angry waters below. From the Buttery Elevator to Suspension Bridge the survey was made by triangulation from a base line established on top of the Canadian bank. From the bridge to Prospect Park the work was easier, the line passing over the talus beside the quieter waters of the Upper Channel. An attempt was made to cross-section the line, but it was given up as impracticable, and such estimates of quantities as were ob-

tained must have been arrived at by rough approximation. Invitations were extended to contractors to bid on the work, but, so far as I have been able to learn, they all declined to make proposals based upon quantities. After a brave struggle for existence against the united opposition of citizens, land-owners and interested corporations, the Whirlpool Company rested and took account of its forces, to determine, if possible, upon some more feasible line of battle on which to renew the fight.

In 1889 Capt. J. M. Brinker, of Buffalo, an experienced coal miner and railroad man, formed a company to build the railroad in the gorge from Niagara Falls to Lewiston, and, as will be seen, his plan of extending the line was the salvation of the project. It was the practicable thing to do, for with connections at the falls with the electric and steam roads entering that city, and at Lewiston with the New York Central and the steamboat lines for Toronto, the character of the undertaking was changed in the sight of the law. The new road was to be a double-track, standard-gauge railroad, to be operated by "steam, electricity or other motive power." The stock of the Niagara Falls & Whirlpool Company was purchased, and the new company became the possessor of all rights and privileges enjoyed by the old, and bound to carry out its obligations.

The temper of the people of Niagara Falls was very unfriendly. The *Gazette* of that city of December 27, 1890, said: "The *Gazette* has favored, and will favor, the coming here of all legitimate railroads, but this railroad holds a unique position, and unless its officers act in a very different spirit from that shown by the Whirlpool Railroad, with which it proposes to merge, the *Gazette* questions the advisability of welcoming it with open arms. As to the question of defacement of the natural scenery and the legal question involved, on which the Whirlpool Company has already been beaten in the Court of Appeals, there is plenty of time for future discussion." In the same issue appeared an article descriptive of the new project, in which the Hon. Peter A. Porter, a member of the distinguished Porter family, which, a few years ago, relinquished to the state of New York Prospect Point and Goat Island, that now make up the beautiful Niagara Park, suggested that the two great points of contest would be at the Buttery Elevator and Deveaux College, and predicted a sorry failure for the enterprise.

What the arbitrary methods of the Whirlpool Company failed to secure during its life, Captain Brinker, ably assisted by his counsel, Herbert P. Bissell, with considerable diplomatic skill, acquired in a few months, and in September, 1890, the survey of the new road was begun, retracing as far as possible Mr. Shields's line from Prospect Park to the Whirlpool, and producing it northward to Lewiston, following the irregularities of the bank and keeping about 20 feet above the water. Several parcels of right-of-way were purchased without great difficulty as a result of the more persuasive methods of the new company, but when an attempt was made to secure right-of-way across the lands of the Niagara Falls Hydraulic Power and Manufacturing Company, better known as "The Schoellkopf Company," overtures were met by Mr. Schoellkopf with great coolness. He believed that building a railroad beneath the bank in front of his mills would seriously interfere with their operation, and steadily opposed all attempts to secure the coveted strip of land. After many fruitless meetings, legal proceedings were begun against the manufacturing company for condemnation. The case was referred to a commission, many witnesses called, and much expert testimony was given. Mr. Wallace C. Johnson, member of the American Society of Civil Engineers, engineer for the Schoellkopf Company, testified that the railroad would seriously hamper his company in its work, and that it would be impossible to so build it as not to practically destroy the value of the water-power of his company. He produced plans showing the great power-house about to be built at the foot of the bank, which now supplies electric energy propelling the cars of our road. After the testimony was all in a trip of inspection was made, when the commission, accompanied by the principals in the action, with their attorneys and engineers, were conveyed by the little steamer "Maid of the Mist" along the bank of the river as far northward as it was safe to go, obtaining an accurate view of the location. The verdict of the commission was favorable to the railroad company, but imposed the condition that in passing the side of the intended power-house of the Schoellkopf Company, the line should be diverted out side of the proposed building. An appeal taken from this decision also resulted favorably to the railroad, and the final outcome of the litigation greatly enhanced its reputation. It was now determined beyond question that the Niagara Falls & Lewiston Railroad, unlike its predecessor, was a full-fledged railroad within the meaning of the statute.

A strong enemy of the original road remained; namely, Deveaux College, but the trustees of this institution, evidently impressed with the strength of the new company, avoiding litigation, entered into negotiations for the sale of right-of way desired, a price was agreed upon, and the fee of the land passed into the company. The Buttery Elevator was next obtained for $119,000, and the Van Horn and Rapids View elevators for $90,000. As will be seen from these figures, the right-of-way was expensive. After these significant victories the owners of the balance of the land became more tractable, and by commission or purchase the entire right-of-way from Niagara Falls to Lewiston was obtained in reasonable time. As is usual in all railroad locations, the owners, protesting that their property would be ruined, adopted such methods as would secure for them the highest price for their land. It is difficult to understand to what use they could have put this debris slope, lying from 200 to 300 feet beneath the walls of the gorge, and about as inaccessible as land could be. Mr. Schoellkopf, still anxious to prevent the location in front of his mills, made the valuable suggestion of carrying the line by easy grades up the high bank, and continuing through streets to direct connection with the Niagara Falls Street Railroad. The suggestion at first seemed impracticable, on account of the great height to be overcome to cross over the New York Central tracks on the upper edge of the cliff, but careful examination determined the feasibility of an undercrossing, reducing the height to be overcome about 40 feet. The final location of the crossing of the Central and the line in Second street was not made until after much of the lower part of the road had been built and put in operation.

The peculiar location of this railroad and the unusual difficulties attendant upon its inauguration seemed to warrant the somewhat long description I have given of the business side of the enterprise. Less enthusiasm and less determination than was possessed by the officers of the new company would have resulted in discouragement before reaching the time for construction.

In order that we may better understand the actual operation of building, I will refer briefly to the geology of the gorge, with which some of you may not be entirely familiar. For our purpose the gorge may be best considered as made up of three distinct sections: the upper or newly made channel, excavated by the constantly receding falls; the middle or original channel, which is of preglacial origin, and the lower or postglacial channel. The characteristics of the typical cross-sections of these three channels are widely different. The preglacial section is of least

FIG. 2.—"BUILDING THE NIAGARA GORGE RAILWAY."—FALLEN ROCK MASSES ON THE LINE.

width, and has nearly vertical walls extending almost to the water on the American side. The postglacial section is wider and has vertical walls to about one-third the depth of the gorge, and steps down to the water which are covered with debris that has accumulated by regular contribution from the exposed walls above. The new section, which extends southerly from the railroad bridges, is much wider than the preglacial channel and has slopes or tali reaching nearly to the tops of the cliffs. This debris is much deeper than that resting on the steps of the lower channel, and no excavation has as yet been made of sufficient depth to disclose the steps.

The river is now flowing through the Medina sandstone, which underlies all western New York. The railroad at frequent intervals passes through sections of sandstone, and practically all the rock excavation was made in the quartzose belt of this stratum. Above the sandstone lies the Clinton limestone, over that the Niagara shale, and at the top of the cliff, the Niagara limestone. While the railroad follows the irregular line of the foot of the talus from the Whirlpool to Lewiston, the directions of the entire channel form, roughly speaking, four tangents. The new channel is about two miles long and extends, approximately, northeasterly from the present fall to the railroad bridges. The preglacial channel is about one mile in length from the bridges northwesterly to the Whirlpool. The waters leave the Whirlpool in a direction nearly at right angles to that at which they enter, and continue northeasterly to the Devil's Hole, a distance of about two miles, and from the Devil's Hole to Lewiston, about two miles more, running almost due north. The continuation of the preglacial channel, known as St. David's, lies directly to the northwest in the extension of the line of the Whirlpool Rapids, and is plainly marked, but is nearly filled with glacial drift.

About the 1st of April, 1895, an agreement was entered into with Messrs Crage & Tench, contractors of Buffalo, to build the Gorge Railroad, in which the contractors were to secure the men, furnish all necessary tools, and their services for 10 per cent of the force account. After five tedious years of waiting the company suddenly decided to proceed with construction, and I received a telephone message from President Brinker to the effect that "the graders would be at Lewiston to start work to-morrow morning," and asking me to be on hand to give necessary directions. Construction was begun at Lewiston on April 11, and a few weeks later at several points along the line between Lewiston and the Buttery Elevator. Beyond a profile, which it was afterward found impracticable to follow, no plans were made as the result of the original survey.

I am now confronted with a task more difficult than that of building the railroad—how to tell you in engineering terms of the construction of this road that was built in a most unscientific manner. My orders were to put a railroad in this unpromising place, and I proceeded forthwith to obey. Before stakes were set a path was graded, following, as nearly as possible, a few feet above the proposed grade-line, and gangs of laborers were placed at frequent intervals. No reliance could be put upon any slope made outside of the natural slope. Had classification been attempted, but two kinds of material would have been named—loose and solid rock, as the talus is made up of large and small stones, with not sufficient earth to fill the interstices, and with no cementing material, although the roots of dense vegetation tend to hold it in place and maintain a much stronger slope than would otherwise be possible. The deep channel of the river afforded the very best place for wasting the material excavated, and work proceeded rapidly. From 600 to 1,000 men were employed, and the first five miles to Buttery Elevator roughly completed, and one track laid, and the first train entered this temporary southern terminus August 25. On the inner side of the road-bed such a slope was formed as would stand for the time being, which, of course, meant that the heavy rains and the frost in the coming Spring would bring down large quantities of material left on the steps above. Cross-overs were placed at such points as seemed to threaten most, and, from time to time, as slides occurred, the road was operated with single track in that section, and large numbers of men quickly removed the encroaching talus. Several slides took place in the early Spring of 1896 and again in the Spring of 1897. The quantities decreased each year. A view of the slide of this Spring, at the same point where occurred the greatest encroachment in 1896 and 1897, shows how surely the slopes are being reduced to an angle of repose and are taking on the appearance of stability. New vegetation adds greatly to their permanence and more agreeable appearance.

(To be concluded.)

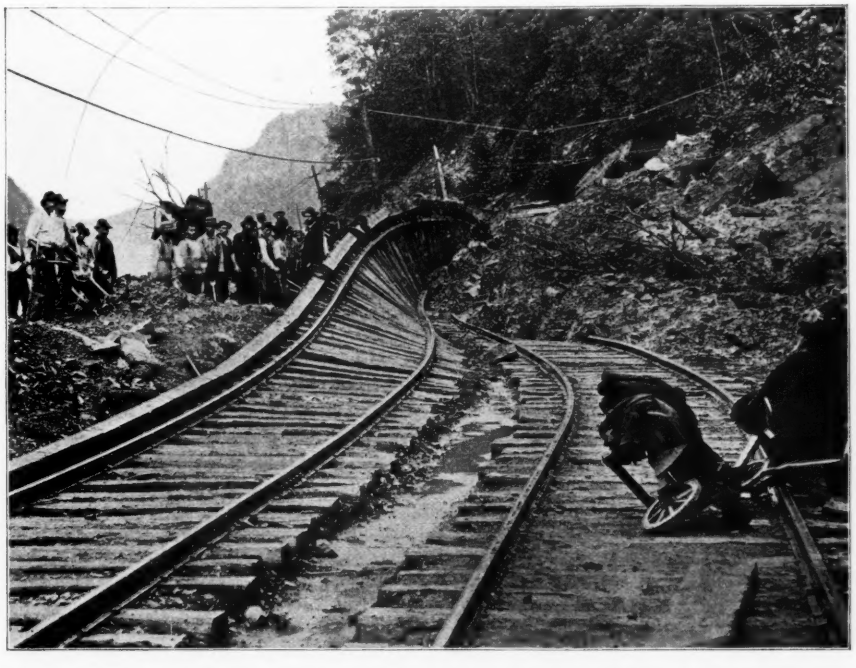


FIG. 3.—"BUILDING THE NIAGARA GORGE RAILWAY."—EFFECT OF A LANDSLIDE ON THE TRACKS.

"The Automobile."

On July 29 the ELECTRICAL REVIEW received from the U. S. Industrial Publishing Company, of New York city, an artistic prospectus of a monthly magazine to be issued in October, 1899, entitled "*The Automobile:* An Illustrated Monthly Magazine Devoted to the Interests of Horseless Traction. Edited by Sylvester Baxter and E. E. Schwarzkopf." The prospectus appeared to be a facsimile of the cover of the proposed magazine and carried no evidence of a copyright.

On August 7 the ELECTRICAL REVIEW received No. 1, volume I, of *The Automobile* for September, 1899, published by the E. L. Powers Company, of New York city. The paper is illustrated and consists of eight pages. Below the title is this: "Copyrighted, 1899, by the E. L. Powers Company."

Which is it to be—*The Automobile* or *The Automobile?*

Mr. Sylvester Baxter is understood to be a newspaper man of some years' experience. Mr. E. L. Powers is known to have had many years' experience as a publisher in the electrical field.

Is it possible that the electrical publisher has "moted" too rapidly for the newspaper man?

Will the result be a newspaper trust thus early in the automobile industry, or will Mr. Baxter have to change the name of his magazine, or what?

Trolley Accident in Connecticut.

A trolley car of the Shelton, Ct., Street Railway Company jumped a bridge 50 feet high near Stratford, on August 6, with unusually disastrous results. Of the 45 passengers on the car 29 were killed and 12 injured. Only four men escaped injury by jumping before the car fell from the bridge. They landed in mud and were unhurt. The car turned over in its descent and struck roof downward. The motors broke through the floor and crushed the passengers. The car is said to have been running at very high speed, and it is reported that there were no guard rails on the bridge.

The Street-Railway Strike in Cleveland.

The strike on the Big Consolidated Street Railway at Cleveland, Ohio, developed but one or two instances of violence during the past week. The troops have been relieved from police duty, and the local authorities are again practically in control of the city. The boycott of the road continues in effect.

SCIENCE BREVITIES.

Spanish Electrical Terms—From the appendix of a dictionary which is shortly to be published by the Academy of Spain we gather, says the *Electrical Engineer*, that certain fixed names for electrical units are to be established, and that these names will be accompanied by definitions which bring the units in line with those used by the rest of the scientific world. The list of these terms is published in the *Telegraphista Espagñol*, and from this it is seen that the names given of the units correspond in derivation with those in use in England and America. For instance, the following terms will be used: *amperio* for ampere, *culombio* for coulomb, *faradio* for farad, *julio* for joule, *omo* for ohm and *vatio* for watt. The last is perhaps the one most easily to be mistaken by any one not having a knowledge of Spanish.

Velocity of Electric Waves in Air—G. V. MacLean has succeeded in devising a form of coherer which is described in the *Philosophical Magazine*, and is quite suitable for the Hertzian experiment of determining wave-lengths from nodes produced by metallic reflection. The coherer employed is one reduced to its elements. It might, in fact, be termed an electro-bolometer, and in general is not more difficult to use than the heat-bolometer. Two globules of platinum, one millimetre in diameter, are attached to the ends of two platinum wires 0.12 millimetre in diameter and 1.7 centimetre in length. These latter form spirals, each of two convolutions, about two iron terminals 1.5 millimetre in diameter and .4 centimeter in length. These terminals run through the center of the two brass caps of a glass tube 8.5 centimetres long, and 1.5 centimetre in diameter. To one of the terminals was connected a micrometer screw, so that the platinum globules could be adjusted to any distance from each other. This constituted the coherer proper. The glass tube was not exhausted; it served merely to protect the globules from rust, dampness or external interferences. The curves of maxima and minima away from the mirror are very expressive. The velocity of propagation was determined from the wave-length and the period of oscillation, as indicated by spark photographs, and came out as 2.991×10^{10} centimetres per second; i. e., practically the same as along wires.

Leakage of Electric Charge—J. C. Beattie, according to the *Philosophical Magazine*, constructed a kind of double air condenser consisting of two horizontal zinc plates enclosed in an iron box, and heated up to temperatures varying from 250 degrees to 300 degrees. The plates were charged to potentials varying from 80 to 240 volts, and the fall of potential was observed by means of a multicellular voltmeter. It was found that no increased leak took place in consequence of heating, either when the zinc plates were bare or when they had water on them. Nor was there an increase of leakage by the evaporation of iodine or bichromate of potash. But a very decided leakage was obtained on coating the zinc with mixed bichromate and iodine and heating the mixture. Zinc sulphide had the same effect. On the other hand, fluorescent bodies like the sulphides of calcium and barium produced no effect, not even when sprinkled with iodine. The leakage is therefore not immediately connected with luminescence. On substituting iron plates for the zinc plates leakages were obtained by means of coatings of permanganate, mixed black oxide of manganese and potassium chlorate, and potassium acetate, all heated, but not with uranium nitrate, sulphides, or bichromate, even when sprinkled with iodine.

Quick Method of Calculating the Weights of Conductors—An interesting method of rapid calculations, and more especially comparisons between the costs of different materials for the line, such as copper, iron or aluminum, is described in *L'Industrie Electrique* and abstracted in the *Mechanical Engineer*. The mass, that is, the weight, of a line of given length and resistance is proportional to the product of the resistivity (that is the special resistance) and the density of the material, both of which are physical constants. This product for iron is 78, for copper 14.24, and for pure aluminum 7.54; the weight of metals for lines made of these materials will therefore be in the proportion of these figures. If, for instance, the cost per pound of aluminum is about double that of copper, then the cost of the line will be equal for these two materials, because 14.24 is about double 7.54; when the cost of aluminum becomes less than that, it will be the cheaper of the two metals. The actual weight of a line in kilograms is determined by the following formula, in which L is the length going and returning, in meters, R the total resistance in ohms, r the specific resistance in microhms per cubic centimeter, and D the density:

$$W = \frac{L^2 rD}{R \times 1000}.$$

For commercial copper at 15 per cent. C, the product of rD, may be taken to be equal to 16, and the value of r is readily determined from the allowable loss in the line.

Benjamin Franklin's Kite Experiment—The famous experiment of Benjamin Franklin, whereby he demonstrated the identity of lightning and the electric spark, is thus described by the experimenter in a letter written October 19, 1752:

"Make a small cross of light sticks of cedar, the arms so long as to reach to the four corners of a large, thin silk handkerchief when extended. Tie the corners of the handkerchief to the extremities of the cross, so you have the body of a kite which, being properly accommodated with a tail, loop and string, will rise in the air like those made of paper, but being made of silk is better fitted to bear the wet and wind of a thunder gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp-pointed wire rising a foot or more above the wood. To the end of the twine next the hand is to be tied a silk ribbon, and where the silk and twine join a key may be fastened. This kite is to be raised when a thunder gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon as the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite, with all the twine, will be electrified, and stand out every way and be attracted by an approaching finger. And when the rain has wet the kite and twine you will find the electric fire stream out plentifully from the key on the approach of your knuckle."

The experiment was repeated first by McAdie at Blue Hill Observatory, some 10 miles southwest of Boston, 133 years after its first trial. There were two large kites silk-covered and tin-foiled on the front face. These were of the ordinary hexagonal shape, for in 1885 Malay and Hargrave kites were unknown. Fifteen hundred feet of strong hemp fish-line was wrapped loosely with uncovered copper wire of the smallest diameter suitable, and this was brought into a window on the side of the observatory, through rubber tubing and blocks of paraffin. Pieces of thoroughly clean plate-glass were also used.

"Perhaps the most noteworthy result of these earlier experiments," says Mr. McAdie, "was the discovery (for such we think it was) that showery or thunder-storm weather was not the only condition giving marked electrical effects. The electrometer needle would be violently deflected and large sparks obtained at other times. Day after day as we flew the kite we found this high electrification of the air, and we had no trouble in getting sparks even when the sky was cloudless."

During later experiments a kite was flown successfully through a thunder-shower. The description of the phenomena in a recent government report, entitled "Lightning and the Electricity of the Air," is very interesting. "About 11 A. M. the kite was sent up, and it remained aloft until after 10 P. M. From the observatory one can see to the west 50 or more miles, and a thunder-storm came into view just about sunset. The kite was flying steadily, and whenever a finger was held near the kite wire there was a perfect fusilade of sparks. As the darkness increased, the polished metallic and glass surfaces in the large electrometer reflected the sparks, now strong enough to jump across the air gaps, and the incessant sizzling threatened to burn out the instrument. The vividness of the lightning in the west also made it plain that the storm was one of great violence, and as the observatory itself would be jeopardized, one of the four men present proposed to cut the wired string and let the kite go. But even that was easier said than done, for to touch the string was to receive a severe shock. It was necessary, however, to get out of the scrape, and one of the party took the kite string and broke the connection with the electrometers and insulators. While he was in the act of doing this, the others, who by this time were outside the building, saw a flash of lightning to the west of the hill. The observer who was undoing the kite wire did not see this flash. He saw a brilliant flare-up in the electrometer, and at the same instant felt a severe blow across both arms. Notwithstanding, he loosened the wire, and, dropping an end without, it took but a few moments to make it fast on the hillside some distance away from the observatory. There it remained for the rest of the night. A 105 volt incandescent lamp was placed between the end of the kite wire and a wire running to the ground. There was some light, but no incandescence of the filament. It was more in the nature of a creeping of the charge over the outer glass surface of the lamp. Stinging sparks were felt whenever the kite wire was touched."

ELECTRIC RAILWAY NOTES.

Work has been commenced on the power-house of the Rapid Railway at New Baltimore, Mich.

The Hartford & West Hartford Street Railway Company's suburban line to Unionville, Ct., has been sold at a receiver's sale for $20,000.

The Union Traction Company, of Philadelphia, reports a net profit for the past fiscal year of $600,000, as against $24,620 the previous year.

The Montreal, P. Q., Street Railway Company has provided accident insurance for its employés injured while in discharge of their duties.

Judge Williams has sustained the injunction to prevent the refunding of the Syracuse, N. Y., City Railway bonds to the amount of $1,000,000 at four per cent.

A decision has been handed down in the Circuit Court at Detroit, Mich., enjoining the street-railway companies from carrying freight over their lines within the city limits.

A writ of certiorari has been secured against the franchise granted by the Gloucester, N. J., City Council to the Delaware & Atlantic City Railroad Company.

The artesian well at the site of the power-house of the Inland Traction Company at Souderton, Pa., has been completed. The depth is 314 feet. The supply of water is 70 gallons per minute.

It is said that an English syndicate has agreed to provide funds for constructing a dam, reservoir and power-house on the Platte River, to generate electricity to supply light, heat and power in Omaha.

New York capitalists are said to be interested in the Frederick, Thurmont & Northern Electric Railroad, which is believed to be part of a project to build a trolley line from Washington, D. C., to Gettysburg.

Alexander Brown & Son, of Baltimore, have secured control of the Peninsular Railroad, of Newport News, Va. These interests now own two electric lines between Newport News and Old Point Comfort.

It was rumored in Newark, N. J., last week that all the trolley interests and electric light and gas companies in eastern and northern New Jersey will be consolidated under the control of the Philadelphia Gas Improvement Company.

The Parkersburg, W. Va., City Council Committee, appointed to consider the granting of a franchise to the Parkersburg & Marietta Traction Railroad, has reported adversely, so the electric road between the two places has been abandoned.

Articles of incorporation have been filed by the Indianapolis & Martinsville, Ind., Traction Company, of Indianapolis, for $500,000, with P. H. Fitzgerald, Sterling R. Holt, J. C. Tarkington, Frederick Joss and Joseph T. Elliott, Jr., as stockholders.

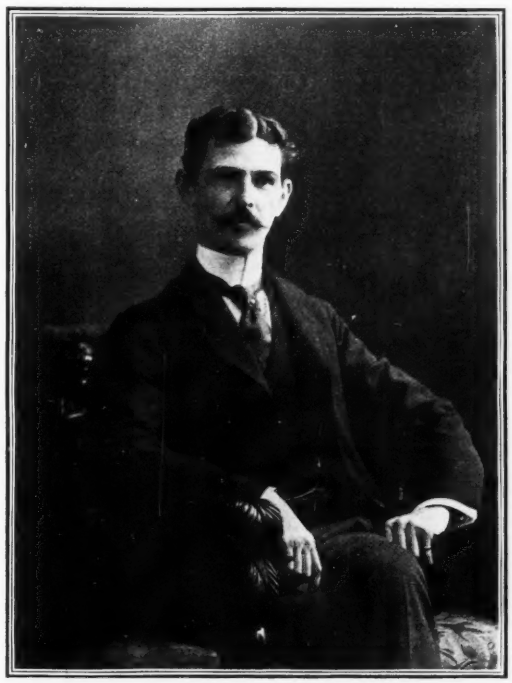
The Lexington, Ky., City Railway has filed a $1,500,000 mortgage in favor of the Columbia Trust Company, of Baltimore. The money is to be used in extending and improving the local street-railway system. Perhaps suburban lines will be built.

A brick addition is being built to the auxiliary power-house of the Philadelphia & West Chester Electric Railway, at Ridley Creek, Pa., in which will soon be placed a big converter to enable the road to increase the amount of current at the West Chester end.

A meeting for the general reorganization of the St. Louis street railways, purchased by Brown Brothers, of New York, has been called for September 20. The stockholders of all the St. Louis lines will meet and consent to the issuance of the companies' bonds to the extent of $45,000,000.

The Westinghouse company has just completed the electrical equipment for the Stillwater & Mechanicville, N. Y., Electric Railway, which will be built along the Hudson River a distance of nine miles, to complete trolley connection between Albany and Troy. The power will be furnished by the transmission plant at Mechanicville.

At a recent meeting of the International Traction Company, of Niagara Falls, the following officers were elected: President, W. Caryl Ely; vice-president, Col. D. S. Lamont; secretary and treasurer, R. F. Rankine; general manager, Burt Van Horn; directors, C. H. Coster, Col. D. S. Lamont, Francis Lynde Stetson, William B. Rankine, T. DeWitt Cuyler, Burt Van Horn and W. Caryl Ely.



HENRY SANGER SNOW, TREASURER OF THE NEW YORK & NEW JERSEY TELEPHONE COMPANY.

At Columbus, Ohio, the United States Court has ordered the sale of the Columbus Central Street Railway and the Minerva Park, which is controlled by the railway. Entry is now prepared and judgment will be taken for $1,700,000, which includes the bonds and $200,000 interest. The road will be purchased in the interest of the Columbus Street Railway, and as soon as the legal complications are overcome there will be a consolidation.

The motormen and conductors of the Chattanooga, Tenn., Electric Street Railroad a few days ago attempted to organize a union to secure an advance in wages. The company discharged four of the leaders of the movement, and President Warner issued a written order positively forbidding employés to join a union. On August 3 the motormen and conductors met and organized. The company issued an ultimatum giving the men 10 days to withdraw from the union. The men are firm, and a general strike seems inevitable. Organized labor in Chattanooga is boycotting the road. One hundred men are affected.

The electric locomotive constructed by Messrs. Brown, Boveri & Company, destined for the Jungfrau Mountain Railway, is said to be the most powerful rack-wheel machine hitherto constructed, and is designed to haul trains over the steepest portion of the road. The motors are placed under the passenger cars, whereby greater adhesion between the driving-wheels and rails is obtained. The car truck is provided with two bearing axles and two driving axles, the latter being situated between the former. Two motors, each of 125 horse-power, at 800 revolutions per minute, actuate the toothed wheels through the medium of duplicate gearing. If required, these motors are capable of working up to 300 horse-power. The driving current is conveyed overhead at a tension of 500 volts. The pivots of the toothed wheels are of aluminum-bronze, the teeth being of cast-steel.

Henry Sanger Snow.

Mr. Henry Sanger Snow, whose portrait the ELECTRICAL REVIEW takes pleasure in publishing herewith, is known to electrical people as the treasurer of the New York & New Jersey Telephone Company, of Brooklyn, N. Y., which position he has occupied since 1893. Mr. Snow has just been elected president of the Polytechnic Institute, of Brooklyn, with which he has been identified for many years, and of which he has been a trustee since 1888.

Mr. Snow was born in Brooklyn in 1856, studied law in New York city, and practiced his profession until he entered the telephone field. He has received the degree of LL. B. cum laude, from Columbia College, and that of LL. M., from the University of the City of New York. He is a director of several railroads, treasurer of the Brooklyn Library and a director of the Brooklyn Public Library. Mr. Snow will not give up his business connections and has assumed the presidency of the Polytechnic Institute only until the right man for a permanent president may be found.

Electrical Review

OLDEST ELECTRICAL WEEKLY IN THE UNITED STATES.

TIMES BUILDING, 41 PARK ROW,

P. O. BOX 2339. NEW YORK.

NEW YORK, AUGUST 9, 1899.

CHARLES W. PRICE, - - - - - - EDITOR.
STEPHEN L. COLES, - - MANAGING EDITOR.
CHARLES T. CHILD, - - TECHNICAL EDITOR.
STEPHEN H. GODDARD, ADVERTISING MANAGER.

REGISTERED CABLE ADDRESS:
"ELECTVIEW," - - - NEW YORK.

TELEPHONE CALL, 1546 "CORTLANDT."

NEW YORK OFFICE:
RUSSELL HOWLAND, GENERAL REPRESENTATIVE,
Times Building, 41 Park Row.

WESTERN OFFICE:
FRANK E. COLBERT, REPRESENTATIVE,
935 Old Colony Building, Chicago.

WASHINGTON OFFICE:
GEO. C. MAYNARD, - REPRESENTATIVE,
Room 102, Washington Loan and Trust Building,
WASHINGTON, D. C.

LONDON OFFICE:
HENRY W. HALL, - - REPRESENTATIVE,
42 Old Broad Street, LONDON, E. C.
News, Subscriptions and Advertisements.

SPECIAL NOTICE TO ADVERTISERS.

CHANGES for advertisements must be in this office by Friday noon for the following week's issue
NEW ADVERTISEMENTS should be in the office not later than Saturday noon to insure publication the following week, although it is occasionally possible to get in matter received on Monday.

Subscription to the ELECTRICAL REVIEW.

One Year, United States and Canada, - - $3.00
One Year, Foreign Countries, - - 5.00
Single Copies, - - - - - - - - - .10
Copies can be supplied for only one year back, at 25 cents each.

CONTENTS.

Views, News and Interviews	81
Building the Niagara Gorge Railway	81
The Automobile	83
Trolley Accident in Connecticut	83
The Street-Railway Strike in Cleveland	83
Science Brevities	84
Electric Railway Notes	85
Henry Sanger Snow	85
English and American Methods of Getting Business	86
Personal	87
Automobile News	87
Progress in Automobiles	87
Automobile Patents for Sale	87
Obituary	87
Wall Street and the Electrical Stock Market	87
An Arc Lamp Inquiry	87
Duplex Telephony	88
Electric Light Flashes	90
Telephone News and Comment	90
A Flexible Trolley Ear	90
A New Alternating Enclosed Arc Lamp	91
Canadian Niagara Power Company	91
Essentials of Telephone Construction	91
Elements of Design Favorable to Speed Regulation in Plants Driven by Water-Power	93
Advance Information	96
Kindred Interests	xvii
Electrical Patents	xvii
Industrial Notes	xviii
Stock Investments	xviii

Advertisers' Alphabetical and Classified Index on page xiv.

ENGLISH AND AMERICAN METHODS OF GETTING BUSINESS.

In the general chorus of alarm and protest which is ascending from the British technical press at the spectacle of American manufacturers capturing large contracts in their immediate territory and invading the very stronghold of British trade, there is an occasional clear voice that commands attention. Such a one is that of the *Mechanical World*, which, in a leader on American competition in the English machine-tool market, makes the following sensible statements:

"Undoubtedly we are indebted to American designers for many practical notions, . . . but in general it may be said that the conservatism which still dominates our business methods has much to do with the apparently indifferent showing made by our machine-tool makers in comparison with American manufacturers. Probably in no respect is this clinging to old ideas more evidenced than in regard to the manner in which the merits of a tool are brought to the notice of prospective buyers. In England we rarely meet with a catalogue which gives such detailed particulars, drawings, etc., as will enable the actual construction of the machine to be made out, and a probable estimate of its capabilities obtained. Instead we are usually treated to a number of large woodcuts, together with a few leading dimensions, weights, etc., which give the prospective buyer little or no information on the points of the machine in question. Similarly, in the descriptive accounts of machine tools in the technical press, we find that as a general rule only the most meager information is vouchsafed by the makers. On the other hand, the American machine-builder takes the prospective purchaser into his confidence in this respect, giving information which would almost enable any builder, who is so disposed, to make the machine. English builders still object strongly to this policy of what they consider as 'giving too much away,' but facts are against them if the success of American tool-makers is conclusive evidence on the matter. And when all is done and said, English tool-makers competing with American concerns will find they will have to conform to the newer order of things. The American has set the pace, and more up-to-date methods are no longer to be questioned on the score of expediency, but have become absolutely necessary under the stress of competition."

This is an accurate statement of the facts, and contains much meat for reflection on both sides of the Atlantic. If American supremacy in a new market is largely due to the practice of giving explicit information in trade catalogues, it is, without doubt, true that equally explicit information, given in an advertisement of any other character, will be of value to the advertiser. The same difference to which our contemporary calls attention with regard to catalogues exists also between English and American class-journal advertisements, though to a lesser degree. The English notices are marked by generalities, the American by explicit statements. But this is not so generally true as it ought to be. There is a vast waste of advertising space by those who do not describe concisely and intelligibly what they have to sell. It stands to reason that if a man is in need of supplies of any sort, he will buy from that concern which, other things being equal, shows him the more clearly what it has to offer.

The comment quoted above is a tribute of no small value to American business methods. Our British friends will doubtless soon learn the wisdom of a clearer statement of the facts about their manufactures, but it is, meanwhile, entirely possible for our own manufacturers to exceed the present excellence of their advertising literature. It is a subject to which far too little attention is given.

Once in a while every central station is troubled by an irruption of Welsbach lighting in its territory. Just now New York city is going through a mantle-burner period in certain districts, which will, of course, come back penitently to the incandescent light after a season of dalliance with gas. The difficulty is that the stations lose customers during the time it takes the deluded ones to find out that the Welsbach is not all that is perfect, while the customer himself is put to the expense of buying burners, and many, many mantles. This is where the defect of the Welsbach lies. It is apparently a cheaper light than the incandescent lamp, but it really is not when the cost of mantle renewals is figured in with that of gas consumed. The additional disadvantages of vitiated air, heat, fire danger, and the ghastly color of the light from new mantles, soon make themselves evident to the user. There should be some missionary work done by the lighting stations to prevent their customers making costly and unnecessary experiments with gas.

The possibilities of rapid transit service in New York city, even with the present elevated railway structures, are well illustrated on the Second avenue line of that system. Every day the Manhattan Railway Company runs an express train from Hanover square station to the Willis avenue station in 18 minutes. The distance is about eight miles. The route includes several curves and one stop. When the electrical equipment of the elevated system is completed and some of the curves in the existing lines, perhaps, are straightened out, there should be no reason for a lack of genuine rapid transit for at least a part of the New York traveling public.

The unsatisfied demand for copper in all branches of the electrical industry, as well as in others of the mechanical arts, is the important question of the moment. The production of copper during the last year shows an increase of less than four per cent, while the consumption has increased nearly 50 per cent. The major portion of this increased demand comes from the electrical industry, in all branches of which unprecedented activity is apparent. Efforts have been made to find a substitute for copper, but without success in discovering a metal suitable for use in small electrical apparatus. In a few instances aluminum has been used for bus-bars and feeder cables, but the bulk of this metal necessary to secure the requisite conductivity precludes its use except for the purposes noted. We must have more copper or a suitable substitute. The man who finds either is sure of his reward.

PERSONAL.

Mr. Geo. A. Redman, of the Rochester, N. Y., Gas and Electric Company, is visiting New York city.

Mr. Morris W. Mead, chief of the electrical bureau of Pittsburgh, Pa., was among last week's visitors to New York city.

Mr. H. J. Medbery, of Ballston, N. Y., who is well known to the electrical fraternity, spent a part of last week in New York city.

Mr. T. Katayama, chief architect of the Japanese imperial household, who has been visiting New York city, went to Chicago last week.

Mr. W. J. Johnston, formerly proprietor of the *Electrical World*, will sail from San Francisco on August 17 on an eight months' tour around the world.

Dr. Adelbert Von Waldenhofen, professor of applied electricity at the Vienna School of Technology, has retired, after more than 50 years of service.

President Rossiter, of the Brooklyn, N. Y., Rapid Transit Campany, last week denied the rumors, believed to have been circulated by stock jobbers, that he intended to resign. He said he had no trouble whatever with the directors, and that he expected to retain his place for several years.

Professor George Forbes, of London, the well known electrical engineer, has been visiting Niagara Falls, the guest of the officials of the Niagara Falls Power Company. Professor Forbes was connected with the power company when the harnessing of Niagara's energy was first undertaken.

Mr. J. B. O'Hara, for six years managing editor of the *Western Electrician*, has retired after a connection of over 10 years with that journal, and has assumed the management of *Modern Machinery*, a monthly magazine published in Chicago. Mr. O'Hara's many friends in the electrical field, among them the ELECTRICAL REVIEW, will be glad to see him achieve a full measure of success in his new undertaking.

After eighteen and one-half years' connection with the General Electric Company and its predecessors, Mr. William H. Meadowcroft has tendered his resignation, which took effect on August 5. He has accepted the position of general manager of the Perret Storage Battery Company, of New York city. On the evening of August 4, Mr. Meadowcroft was given a farewell banquet by his many friends and associates of the Edison Lamp Works, at Harrison, N. J. Mr. Meadowcroft, in a farewell speech, full of pathos, referred with much feeling to the many and earnest friendships he had made and his deep regret at parting. His old friends united in extending to him their best wishes and Godspeed in his new field of labor.

AUTOMOBILE NEWS.

Philadelphia is to have an automobile club.

Chief of Police Lees, of San Francisco, has recommended the introduction of electromobiles as patrol wagons.

The sight of a man driving an automobile and wearing simultaneously a horseshoe pin in his scarf is said to be as painful to the thorough dresser as tan shoes with a silk hat. —*New York Sun.*

An automobile has beaten a railroad train in a 226-mile race. But then it was a Continental train. They called it an express, but it made only a little over 20 miles an hour.—*New York Tribune.*

A parade of automobiles may take the place of the coaching parade in Newport this season. Mrs. Hermann Oelrichs, who was the first woman to use an automobile at Newport, has consented to get it up and will have the assistance of Mrs. Stuyvesant Fish.

Arrangements are being made for a test of an automobile mail collecting wagon in Washington, D. C. It will not have room for clerks, but will be used simply to collect the mail from the letter boxes and deliver it at the city post office, as is now done by the carriers in their wagons.

With a view of testing the value of automobiles for the collection and delivery of mail, the Post Office Department has authorized William G. Edens, an assistant superintendent of the Free Delivery Division, who has been investigating this subject, to make a proposition to an Indiana firm of automobile manufacturers to equip the office at Alexandria, Ind.

The youngest automobilist in Newport is Vincent Astor, the seven-year-old son of Col. and Mrs. John Jacob Astor. The other day he had his first ride in one, seated between his father and his governess, and, though somewhat timid at first, soon was at home, and enjoyed the ride immensely. During the drive his father showed him how to manipulate the machine, and he took hold quickly.

Progress in Automobiles.

The self-propelled carriage is going through much the same experience that the trolley car and the bicycle went through. Each of the latter was developed by degrees, and up to a certain point was a good deal of an experiment. At length all difficulties were overcome one after another, simplicity of design was steadily sought and obtained, a growing popularity was achieved, and, finally, the manufacture became so extensive as greatly to reduce the price of production. The automobile is not so cheap to-day as it will be at some future time. Its mechanism is not yet all that could be desired. And there are questions still to be solved as to the best methods of accomplishing certain ends. But the automobile has come to stay. There can no longer be any doubt that it has a great field of usefulness before it. And it is probably only a question of time when it will replace most of the horse-drawn vehicles on city streets and country roads.

To any one who has given much attention to mechanics the electric motor is an ideal device. There is almost nothing about it to get out of order, because there is only one moving part—the armature. The gas engine, like the steam engine, has a number of pieces which may break down, thus paralyzing the whole machine. The motor proper in an electric system is so simple and strong that it can hardly fail one who trusts it.—*New York Tribune.*

Automobile Patents for Sale.

TO THE EDITOR OF ELECTRICAL REVIEW:

Referring to inquiry of "Reader," in your last issue, would say that I have for sale a system for automobile operation, protected by patents issued and pending, which will surpass anything now on the market in 9 points out of 12, and be equal on the other three. I should be pleased to hear from your correspondent.

H. C. SPAULDING.

Boston, August 4.

OBITUARY.

Lemuel Wright Serrell, aged 70 years, died at his home in Plainfield, N. J., on August 1, of paralysis. He was born in London, England, on August 21, 1829, and was a son of William Serrell, a patent lawyer. The family came to this country in 1831 and settled in this city. The son entered his father's office as a boy and finally succeeded to the business. He was well known in electrical circles.

Wall Street and the Electrical Stock Market.

The stock market for the week has been comparatively dull and money has been close. The copper situation is causing great discussion in electrical circles. The increase in production this year has been less than four per cent, while the increase of consumption has been nearly 50 per cent, largely due to rapid growth and extension in the electrical industry. Old mines have been reopened and scrap copper has been sought everywhere, but the relief is slight. The question of where to get copper quickly is already a serious one.

On the New York Stock Exchange General Electric closed the week at 123⅞ bid and 124½ asked, a loss of ½ point for the week. There were rumors during the week that the company would recommend an increase in the common stock by and by, say a $10,000,000 increase, more or less of which would be offered to stockholders at par. The earnings are said to be about 21 per cent on the common stock. Metropolitan Street Railway, of New York, closed at 208 bid and 208½ asked, a loss of 4 points for the week. Third Avenue Railroad, of New York, closed at 185 bid and 187 asked, a loss of 3 points for the week.

On the Boston exchange American Bell Telephone closed at 346 bid and 350 asked, showing no change for the week. Erie Telephone closed at 97 bid and 98 asked, a gain of 1 point for the week.

On the Philadelphia exchange Electric Storage Battery common closed at 154 bid and 156 asked, a gain of 3 points for the week. Union Traction closed at 41¾ bid and 42 asked, a loss of ¼ point for the week.

On the curb, or outside market, in New York Electric Vehicle closed at 98 bid and 100 asked, showing no change for the week. Electric Boat closed at 11 bid and 14 asked, a loss of 2 points for the week.

Wall Street, August 5.

An Arc Lamp Inquiry.

TO THE EDITOR OF ELECTRICAL REVIEW:

Could you, through the columns of your valuable paper, give us the name of the firm who manufactures the miniature arc lamps used on the gallery of Madison Square Garden during exhibition of 1896? They were very small, about 12 to 15 inches long, and were rated at 600 candlepower, two amperes. Hoping you will be able to give us the desired information,

M. E. WALSHE & SONS.

Syracuse, N. Y., July 28.

DUPLEX TELEPHONY.*

BY POST INSPECTOR SCHWENSKY.

Apart from the greater cost of the line material and the necessity of metallic circuits, an increase of telephonic traffic between different localities is harder to meet than an increase in the number of telegraphic messages, because it is not possible to better the efficiency of the line by a change in the method of working, as, for instance, from the Morse to the Hughes system. It is therefore a matter for surprise that the duplex working has been relatively but slowly evolved in telephony. The first trials in this direction were made some 15 years ago. In the simplest form, the connections took the shape of a Wheatstone bridge (Fig. 1). At each end of the metallic circuit MN, and as a shunt to the apparatus $A\rho$, two rheostats r r_1 were connected, and between these a wire was led through the second instrument CA to earth. The currents between the apparatus $A\rho$ flow in the usual way along one line and return through the other, while those between the instruments CA flow through the two lines in parallel and use the earth as a return. It is clear from the figure that, so long as the ratio $r/r_1 = a/b$ holds, CA's currents will not flow through $A\rho$. In practice, r and r_1 can be made equal as the go and return line have practically equal resistances.

In testing these connections, however, conversation between the instruments CA was severely hampered by the variable potential difference between the two earthed circuits, and among other things by the noise occasioned by faults in the insulation of the parallel lines. There was also cross-talk between the CA circuit and other single-circuit wires on the same posts. An endeavor was therefore made to improve upon the method by using two metallic circuits and connecting a third, as in Fig. 2, without having recourse to an earth connection. But even with this modification the system did not prove workable in practice. This was chiefly because the size of the resistances r and r_1, which was best for the $A\rho$ circuits, was worse for the CA circuits, and *vice versa*. Only a fraction of the current leaving M passes through the instrument $A\rho_1$, and the remainder passes through the circuits r r_1 at each end, the effect of these shunt circuits being increased by the fact that they are wound non-inductively, while the receiver and induction coil $A\rho_1$ have considerable self-induction. For this reason r and r_1 should be chosen large. Another cause also demands this. It is necessary that the two sides a and b of the metallic circuit, from the point where the CA circuit is branched off, possess approximately the same electrical properties. Otherwise part of the CA currents will flow through the bridged instrument $A\rho_1$ or $A\rho_2$, which will respond to what is spoken into CA. But owing to faults and local causes the electrical properties of the line will vary to some extent, and to make these variations relatively small r and r_1 should have high values. On the other hand, the higher r and r_1 are the worse it will be for speaking on the CA instruments, as these are directly in circuit. In practice it is found that, for the reasons already mentioned, they must, at least, have a resistance of 1,000 ohms each, and, as a consequence, conversation through CA is not so good as in the other instruments. It is true that the eight resistances are not all in series, but in two parallel sets of four each, and that the line resistance is halved by the two lines being in parallel for CA. However, this brings with it the disadvantage that all faults, capacity effects and external disturbances on the lines a and b are added, so far as the CA circuit is concerned, instead of tending to cancel one another. If the subscribers were connected through translators matters were made worse, and the conversation into CA was then almost always heard in the metallic circuit. The cause of this last phenomenon will be considered later.

A considerable step in advance was the proposition by Privy Councillor Elsasser, in 1885, to substitute differentially wound electro-magnets for the direct connections in Figs. 1 and 2. This gave the connections shown in Fig. 3. The translator in common use was employed for this purpose. It consisted of two limbs, upon each of which was a primary and secondary bifilar winding. The current was distributed by this arrangement in a much better manner for the metallic circuit, as the shunts to the transmitters and receivers (the two secondary windings of the translator in series) had a high apparent resistance. The currents from the instrument CA were equally divided between the two secondary windings of the translator, and magnetized the iron in opposite directions. Theoretically, therefore, the core should not be polarized by the currents, and so far as the coils opposed the passage of the current they should act merely as non-inductive resistances. For the same reason these currents would not induce others in the primary winding or the subscribers' line connected to it. If these expectations were not fulfilled in practice, it was the fault of the double-limbed receiver. Owing to the length of the iron, the speaking currents from CA magnetized the core in spite of the two secondary windings being opposed. These, therefore, acted as choking coils, and were detrimental to the speaking currents from CA. In addition, owing to the not inconsiderable capacity between the adjacent secondary and primary windings of the translator, the electrical balance in the metallic circuit was disturbed and cross-talk was occasioned between $A\rho$ and CA. The two halves of the primary winding were in series, one being connected to earth and the other to the subscribers' line. In consequence the currents from CA did not divide themselves equally on the two limbs of the translator, for the side whose primary winding was connected to earth had a higher capacity than the other. The two points of connection of the bridged instrument $A\rho$ did not, therefore, acquire the same potential, and words spoken into the transmitter of CA were heard in the receivers of $A\rho$. If the circuit of the instrument CA is connected to a second metallic line, similarly to Fig. 2, the cross-talk is weakened but not entirely prevented, as the charge taken by the translators on the second metallic line takes the place of the former with connection.

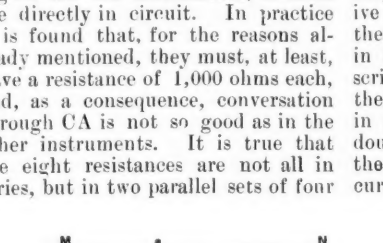


Fig. 1.

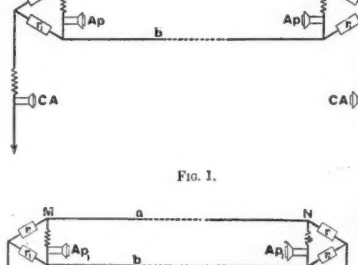


Fig. 2.

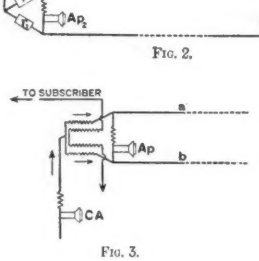


Fig. 3.

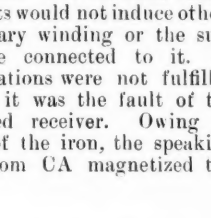


Fig. 4.

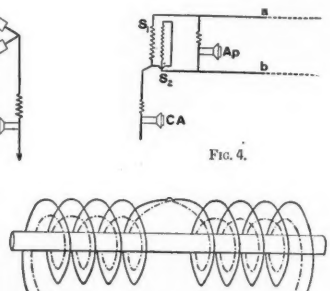


Fig. 5.

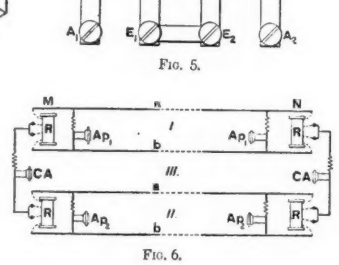


Fig. 6.

FIGS. 1–6.—"DUPLEX TELEPHONY."

After the capacity between the primary and secondary windings of the translator, which is disturbing for other purposes as well, had been practically removed by alterations in its design, great attention was again directed to duplex telephony, both in Germany and abroad. A plan, employed to a certain extent in the United States, England and Scandinavia, is either to branch the extra connection from the middle of the windings of the four translators of two metallic circuits, or, if translators are not used, to connect differentially-wound impedance coils to the two circuits. The capacity between the primary and secondary windings of the translator is removed by abandoning the bifilar method of winding, and putting on the primary first and then the secondary. The secondary windings are bifilar, and particular care is devoted to their resistance and number of turns being precisely equal. The end of one winding and the beginning of the other are connected to one terminal (Fig. 4), which is also connected to the instrument CA. The remaining ends of the secondary are connected to the two wires of the circuit, as seen in the figure.

Although the faults of the two-limbed translator are removed to a very great extent by this construction, a new defect is introduced. As mentioned above, it is preferable to make the resistance of the shunts r r_1 as great as possible. In making the secondary winding, not sufficient care is taken of this. For, as the two halves of this winding are bifilar, and therefore adjacent, there is no inconsiderable capacity between them. The current waves from the apparatus $A\rho$ are, therefore, transmitted from one-half of the winding to the other, without flowing through all the turns of wire. This very appreciably diminishes the apparent resistance of the coil to speaking currents, and deleteriously affects the working of the instrument on the metallic line. It is this circumstance that accounts for the comparatively small distances (to about 50 miles) over which duplex telephony is employed in England. Similar experience seems to have been obtained in Sweden with a pattern of coil recently adopted, in which one-half of the winding is formed by the odd layers (first, third, fifth, etc.) and the other by the even layers (second, fourth, sixth, etc.) of the wire. In this case, besides the capacity between the alternate layers, even if the two wires are charged in the middle of the layers, a complete balance of the magnetization by the smaller and larger windings does not occur.

The German post office, in recent experiments, did not employ either bifilar winding or the Swedish arrangement for the secondary coils. A separation of the secondary winding into two coils, of a similar num-

*Abstract by the *Electrician* of an article in the *Elektrotechnische Zeitschrift*.

ber of turns and equal resistances, placed next to one another on the iron core, did not prove suitable; for, if currents in opposite directions flowed through them, the iron was magnetized and a pole formed between the two coils. Placing the coils over one another did not answer either, for reasons already mentioned. At my suggestion, therefore, the winding was made up of four coils, two inner and two outer, and the inner coil at one end connected in series with the outer coil at the other end. This construction answered admirably. As it appeared that the increase in the secondary turns, necessary to increase the self-induction, prejudiced the action of the coil as a translator, it was not employed for this purpose and the primary winding was omitted.

The duplex coil usually employed is the same in the construction of the core and iron sheath and in the diameter of the wire as the newer translators of the German post office administration. Each of the four coils has about 1,900 turns. The cross-connections between the end of each outer and the beginning of each inner coil are let into the base. The left-hand outer winding begins at the terminal A_1 (Fig. 5), and this winding is connected to the inner right-hand winding which terminates at E_1, as seen. In the same way the right-hand outer winding begins at A_2, and is connected to the inner left-hand winding, whose other end is led to E_2. Normally the terminals E_1 E_2 are connected by a piece of metal as shown in the figure, and the second telephone connection is made at this point, the terminals A_1 and A_2 being connected to the metallic circuit line. Earth is not used, and the connections are effected as in Fig. 6, which speaks for itself.

It is, of course, necessary, to avoid disturbances due to earth currents and induction, that the two pairs of lines be on the same poles; if they were not, it would be, so far as the additional telephone was concerned, as if the go and return wire were separated a considerable distance from one another. The exact agreement between the resistances of the two metallic lines is not very important. Duplex telephony has been carried out without any difficulty with two double lines of two-millimetre and three-millimetre wire, respectively, and, in fact, lines of this smaller wire have been employed with instruments connected to them at intermediate offices (see below) without in the least affecting the duplex working. Naturally there is no longer in such cases electrical balance between the go and return conductor. Cross-talk to other wires on the poles can not occur, however, as these are throughout on metallic circuit. It is possible that two pairs of duplexed lines with unequally loaded conductors might disturb one another if there were an unfavorable arrangement of the wires on the poles, but such a case has always been avoided without difficulty. Taking account of the fact that two lines of the same length and material seldom have the same resistance, no importance is attached to such a careful adjustment of the two windings of the resistance coil, as, for example, in the American apparatus mentioned above. If one-half of the coil has a greater resistance, it is connected to the line-wire with the greater resistance. This diminishes the cross effect of the ringing current, as continuous current is always used for calling up on junction wires of the German state system. On the other hand, a careful test is made of the apparent resistance of the coils to alternating currents, and all coils are rejected the resistance of whose two windings differs by one-half per cent.

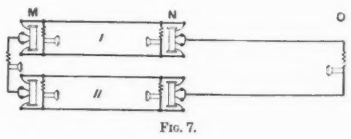


Fig. 7.

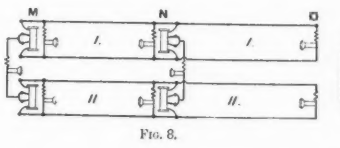


Fig. 8.

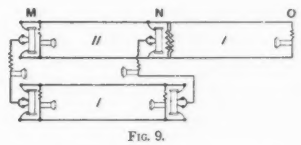


Fig. 9.

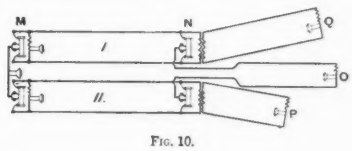


Fig. 10.

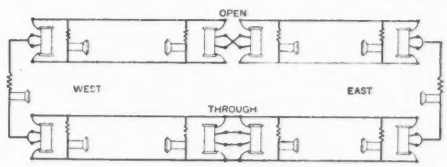


Fig. 11.

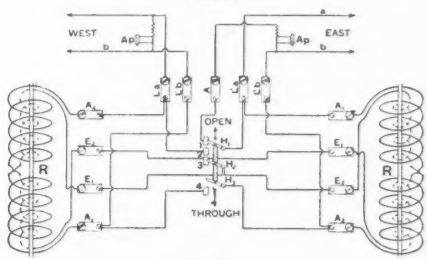


Fig. 12

Figs. 7–12.—"Duplex Telephony."

The employment of duplex connections has not remained confined to the simplest case sketched in Fig. 6. It was first found practicable to connect to the branching terminals E_1 and E_2 of the coils at M or N another metallic line from M to L or from N to O (Fig. 7). This has been used successfully between Berlin-Breslau-Upper Silesia, Berlin-Cologne-Rhine Province, Berlin-Frankfort-Alsace, Berlin-Stettin-Rügen, and Berlin-Dresden-Chemnitz. The two lines can also be extended, as in Fig. 8, or a new independent station can be added between M and N. The connection only becomes less simple when the extension is to be made on only one line, or on both, but in different directions. Then it must be tested in each case whether the extension can be made directly as in Fig. 8, or a translator has to be inserted to avoid disturbing noises or cross-talk in the intermediate circuit. As a rule, the translator (Figs. 9 and 10) is only necessary when the added line has a considerable length. The insertion of a translator is naturally not to the advantage of the communication between M and Q or M and P, as in the German Government service, the subscribers' lines at M, P and Q, being single wire, are also connected by translators to the metallic lines. In the case of subscribers with metallic circuits, however, it appears that this may be done without hesitation. The arrangement also permits the extension of the intermediate circuit from M to L or from N to O (Fig. 10).

If there are intermediate offices in the lines used for duplexing, the connections must be so made that during the time the line is used in the intermediate office and divided for this purpose into two lines westward and eastward of the intermediate office, a connection still remains for the added circuit. On my suggestion this is done in the manner shown in Fig. 11, the details of the intermediate office connections being shown in Fig. 12. The wires to the east and west are permanently connected to the four ends of the windings of two duplexing coils. From each E terminal of the one coil a wire leads to the E terminal of that winding of the second coil which is connected to the corresponding circuit from the other side. The metal bars between the terminals E_1 E_2 of each coil are removed. To change over from the through position to the "open" position, in which the intermediate office can speak, the switch H_1 H_2 H_3 is employed. In the through position H_1 is on 2, and H_3 on 4, and thus a direct path for the current is given between the east and west lines. The coils A_1 E_1 on the one side and E_2 A_2 on the other, connected in series, are, it is seen, short-circuited and removed from the path of the current. The calling and speaking apparatus of one branch is connected in bridge across the line to receive a calling signal if necessary, and the similar apparatus on the other side, being connected to contact 1, is not in circuit. When the switch is moved over to the "open" position, the direct connection between east and west is broken at the switch bars H_1 and H_3. H_1 connects the second apparatus at the intermediate office with the corresponding metallic line, and H_2 connects all the four E points of the coils together at the contact 3. This point affords a connection between the added circuits at the two end points, and conversation can go on undisturbed between these two instruments, while at the same time the intermediate office can speak either east or west. Cross-talk can not take place between the two sides, as they are only connected together at one neutral point. The currents from the added circuits flow in opposite directions round the two coils, so that the latter possess little self-induction. Thus, when the switch in the intermediate office is put over to "open," the effect on the added connection is only to raise the resistance in its circuit by a few hundred ohms. The contact 3 of the intermediate office switch is somewhat longer than 1, 2 and 4, so that when changing over to the open position the arm H_2 makes contact with the contact 3 before the contact of H_1 with 2 and H_3 with 4 is broken.

Up to the present, duplex working is employed between:

	Miles.
Berlin and Cologne	392
Berlin and Frankfort-on-Main	359
Berlin and Breslau	216
Berlin and Hamburg	184
Hamburg and Magdeburg	147
Berlin and Dresden (the added connection extending to Chemnitz. The distance, Berlin–Chemnitz, is 163 miles)	118
Berlin and Leipsic	114
Berlin and Magdeburg	107
Hamburg and Hanover (with the intermediate office Celle in one of the lines)	103
Berlin and Stettin	101
Bremen and Hanover (with intermediate offices at Verden and Nienburg in one of the lines)	76
Leipsic and Dresden	71
Bremen and Hamburg	71
Frankfort and Mannheim	54
Halle and Magdeburg	52
Hamburg and Lübeck (with intermediate office at Oldsloe in one of the lines)	7
Halle and Leipsic (with intermediate office at Schkeuditz in one of the lines)	22
Maintz and Wiesbaden	7
Dresden and Loschwitz	4

The results of working have been thoroughly satisfactory, and a similar system is to be introduced on a number of other lines. Cross-talk, or disturbances from ringing currents in the other circuits, occur seldom, and then only if the symmetry has been disturbed by bad insulation faults.

The employment of these connec-

tions is not necessarily confined to telephony. With some slight modifications they can be adopted for simultaneous telegraphy and telephony on metallic circuits. In this case one metallic circuit line suffices, the telegraphic apparatus being connected between the central point of the branching coil and earth. When, as with Hughes instruments, short, strong current impulses are employed, it is necessary to level these in the usual manner by means of a choking coil and condenser, as otherwise they produce noises in the telephone circuit. The same object may be attained by changing the connection within the branching coil, so that on each side of the middle point of the windings an inner winding and the outer winding lying above it are connected in series. As mentioned above, each half of the winding with the parts of the core and covering belonging to it acts as a single choking coil. Hughes working on metallic circuit telephone lines is employed successfully between Berlin and Franfort-on-Main, and between Berlin and Vienna (411 miles). On the telephone line between Berlin and Frankfort-on-Main an interesting experiment has also been made in using a Hughes apparatus, not on an ordinary metallic circuit, but as the additional connection shown in Fig. 6. The results showed that with good insulation the connection is quite a serviceable one. It is difficult, however, to maintain a sufficiently good insulation continuously on the four wires, and with any leakage there was such a considerable difference between all values of the transmitted and received currents that the Hughes apparatus would not work. Morse working can be maintained longer, and also when faults in the insulation occur the Morse signals do not disturb the speaking lines so much as currents from the Hughes system.

ELECTRIC LIGHT FLASHES.

Perrysburg, Ohio, is to have electric street lights.

Allegan, Mich., will soon have electric lights, supplied by the Kalamazoo Electric Power Company.

The assignees of the Bath, Me., Gas and Electric Company have refused to sell the company's franchise for $130,000.

A contract has been let for a new boiler, engine and dynamo for the Mystic, Ct., Gas and Electric Light Company. This will give the company a double equipment.

Mr. Samuel R. Bullock, of Brooklyn, N. Y., has purchased all the gas and electric properties at Fostoria, Fremont and Sandusky, Ohio, and will unite those of each city in one plant.

The E. P. Allis Company, of Milwaukee, Wis., the well known engine builders, have leased the Lake Erie Engineering Works at Buffalo, N. Y., and expect to have 500 men at work there by September 1.

Telephone News .....and Comment

The local Bell company will erect a new telephone building in Philadelphia. The land has just been purchased for $20,000 and measures 100 by 100 feet.

The stockholders of the Illinois Telephone and Telegraph Company, of Chicago, will meet on August 14 to increase the company's capital stock to $5,000,000, and the number of directors from three to seven.

The new telephone company that was organized last Fall under the name of the Northern Michigan Telephone Company, and that put in an exchange at Traverse City, has been sold on a chattel mortgage to W. W. Wheelock.

The Nebraska Telephone Company has reduced the monthly rental on business telephones in Kearney, Neb., from $3.50 to $2, and residence telephones from $2.50 to 75 cents. An independent company is canvassing subscribers in Kearney.

The Providence, R. I., Telephone Company will increase its capital stock from $1,000,000 to $1,200,000. New stock offered to stockholders at $50 per share is quoted at 99½ bid. The company has been paying eight per cent dividends since 1894.

The Michigan Telephone Company has completed a new line from Detroit west to Kalamazoo, a distance of 130 miles. Ten new copper metallic circuits were strung. Additional circuits on existing lines, and a number of new lines, are now under construction.

Webster Wilder, receiver of the Topeka, Kas., Independent Telephone Company, has commenced three suits in the District Court against stockholders of the company to recover from them under the double liability law. The receiver seeks to secure money to meet outstanding obligations of the company.

The Sunset Telephone and Telegraph Company now has 3,067 telephones in Seattle, 1,400 in Tacoma, 1,800 in Spokane, nearly 300 in Walla Walla, 300 in Whatcom, 100 in Fairhaven, 30 in Everett, 65 in Snohomish, Wash. In each place there has been a marked increase over the number used last year.

The Northwestern Telephone Exchange Company has completed new lines running north from Grafton, N. D., to Langdon, Cavalier, Bath Gate, Pembina, St. Vincent, etc. The line to Bath Gate, Pembina and St. Vincent extends further north than any telephone line in the United States, as these towns are within a few miles of the Canadian border.

President Glidden, of the Erie telephone system, says that company is rapidly securing permanent locations for its central exchange systems in the principal cities of its territory. The company already owns 56 lots of land in 32 cities, and now occupies 25 buildings constructed exclusively for telephone service, with five exceptions. The value of the real estate owned is about $1,200,000.

A FLEXIBLE TROLLEY EAR.

The Plattsmouth Telephone Company, which has been doing business as a company since January 1, 1899, having started with 100 'phones and now having 300, and over 100 miles of toll-lines, have incorporated, with a capital of $50,000; incorporators, Charles C. Parmele, Thomas E. Parmele and T. H. Pollock. They will do a general telephone and telegraph business in Cass County, Neb., with headquarters at Plattsmouth, Neb.

It is reported that the Ohio Valley Telephone Company, which operates the system at Louisville, Ky., under what has been supposed to be an exclusive franchise, is about to have a rival. It has been discovered that an old charter granted 20 years ago is still in force. New York capital has been interested, and a stock company is being organized. The charter is said to be a valuable one and to include electric lighting privileges.

The Cleveland, Ohio, Telephone Company will soon begin the erection of five new exchanges. They are to be buildings of neat appearance and similar in construction to the buildings now used by the company for its branch exchanges. They will be two stories in height, of brick, with stone trimmings, and will be completed before Fall. With the completion of these buildings the company will have nine branch exchanges. The aggregate cost of the buildings will be about $200,000. In addition to this an equal amount will be expended in equipping the exchanges.

The Danville Telephone Company, Danville, Ill., are moving into new and more commodious office rooms, the continued increasing patronage necessitating large quarters. The new exchange room is modern in every respect, the company installing the complete equipment of the Sterling Electric Company, of Chicago, consisting of a 500-number metallic board adapted for an increase to 1,000 numbers, a 500-number metallic distributing board and combined cable terminals and protectors for 500 metallic numbers, together with toll boards, monitor's desk, etc. The Danville company have been making extensive improvements in outside construction.

A Flexible Trolley Ear.

Electric railway construction demands flexibility as much as does our national currency. Inequalities in electric railway grades and levels frequently can not be corrected without much outlay, and a difficulty always is found in gaining uniform tenseness of trolley wires and guys. Any article which automatically compensates these differences is welcomed by electric railway construction firms and owners Wherever flexibility of line results is desired the Wood's flexible trolley ear, as shown herewith, will be most helpful, for it allows both an end and up-and-down movement of the trolley wire It also prevents crystallization of the trolley wire, as is the case in rigid trolley wire supports. It stops all hammering of the trolley wheel, which results in reducing sparking to a minimum. It is claimed to be a matter of economy to use Wood's flexible trolley ear in connection with rigid pole construction, as this ear and rigid pole is about one-fourth the cost as compared with the flexible pole bracket form of construction. The ear is cast in one piece, and is made either in clincher or solder ear form, and is interchangeable for "West End" or "Cap and Cone" types of material. The Central Electric Company, Chicago, carry in stock Wood's flexible trolley ear and a complete line of standard and special electric railway material.

A New Alternating Enclosed Arc Lamp.

The Petite alternating enclosed arc lamp, manufactured by the Western Electric Company, illustrated herewith, is in many respects a radical departure from former practice in this field, and it may be truly considered as embodying the most advanced ideas, both mechanically and electrically. Briefly, it is strictly up to date in all features entering into the make-up of an economical and reliable lamp.

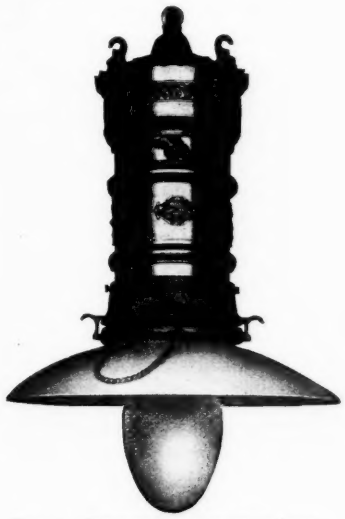


FIG. 1.—PETITE ALTERNATING LONG-BURNING ARC LAMP FOR INDOOR USE.

In the regulating mechanism an induction armature of aluminum is used, so combined with the laminated core of the electro-magnet that great range of adjustment is secured, and the lamp will continue to burn steadily under changes in voltage, which would usually affect such forms of lamp.

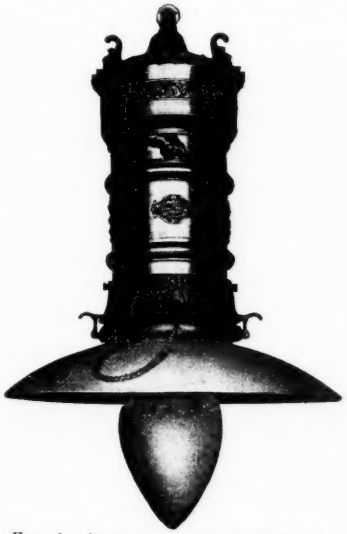
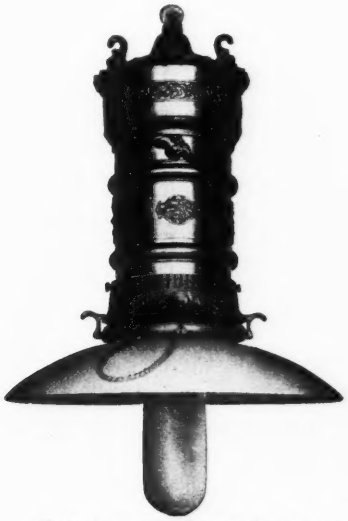


FIG. 2.—PETITE ALTERNATING LONG-BURNING ARC LAMP FOR INDOOR USE.

The carbon is fed directly by a specially designed clutching mechanism, which, while giving precision of feeding, will not allow the carbon to slip through when jarred nor by reason of the mechanical vibrations communicated to it from the mechanism. This is a most desirable feature.

FIG. 3.—PLAIN WEATHERPROOF ALTERNATING LONG-BURNING ARC LAMP FOR OUTDOOR SERVICE.

A simple mechanical balancing of the moving elements in the lamp mechanism, reduces the electrical energy necessary to effect regulation to a minimum with a resulting high efficiency in the lamp.



FIGS. 5 AND 6.—PETITE ALTERNATING LONG-BURNING ARC LAMPS FOR INDOOR USE.

A particularly noteworthy feature of the lamp is the arrangement of the side arms, which support the lower carbon and its holder; these are so located with reference to each other and to the carbons that the usual flaming of the arc and irregular burning away of the tips of the carbons are said to be prevented.

The lamp is short, neat in appearance, easy to trim, and is capable of use with various combinations of globes and shades. It is readily connected for operation in multiple at different frequencies, with simple means of adaptation for voltages varying from 100 to 120, gives a life of 100 hours with each trimming, and is practically noiseless.

When used for outdoor illumination no hoods are necessary, a special weatherproof casing being provided, so constructed that the lamp can be used with a metal reflector, white enameled on the under side to throw the light downward, or with an outer globe with or without a reflector. The inner globe does not require cleaning except at each trimming.

Canadian Niagara Power Company.

The Canadian Niagara Power Company, it is said, has given up its monopoly rights on the Canadian side of Niagara Falls. The company had the sole right to produce power on the Canadian side. For this right it paid an annual rental of $25,000. The Canadians charged that the company did not develop the promised power, but kept other companies from doing so, thus building up the American side. A row ensued and the matter was carried to Parliament. Now the company has agreed to allow other companies to come in and share the right of developing power. The rental is reduced to $15,000 a year and the franchise is for 110 years. The company also had the time extended in which it has to develop power.

ESSENTIALS OF TELEPHONE CONSTRUCTION.*

BY MAXIME REBER.

(Concluded from page 71.)

Satisfactory and efficient service can only be furnished by having all the lines full metallic construction. Grounded lines or common-return lines are objectionable on account of cross-talk and noises from inductive disturbances. Such disturbances can only be effectually guarded against by having both sides of the circuit equally balanced and equally subjected to the same disturbing influence, which can only be done by full metallic construction. Much more satisfactory long-distance service can be furnished to subscribers having full metallic circuits, as no repeating coils are necessary, but connections to the toll lines can be made direct. Common-return lines and grounded lines require the use of repeating coils in connecting up subscribers having full metallic circuits or to toll-lines, and these coils introduce a choking effect on the voice current.

The cost of full metallic construction is, of course, greater than for grounded lines, but the difference in the character of service that can be furnished will generally compensate for the additional expense. Copper wire should be used for all lines, on account of its light weight and consequent decreased load on the pole lines, small resistance and capacity. Copper wire should be hard drawn, and should have a conductivity of not less than 97 per cent, and should conform to the usual requirements for elongation, tensile strength and twists. Joints on copper lines should be made with McIntire or similar sleeves, and the use of soldering irons should not be permitted on hard-drawn copper.

In stringing wire, the wire should be given such a sag, depending upon the temperature at the time of stringing, that in very cold weather the lines will not be drawn up too tight. In case the expense of copper is prohibitory, then iron lines may be used for local distribution and for short toll-lines, but such iron should be of good quality, with a low ohmic resistance, and be well galvanized.

Gases and fumes from manufacturing establishments in cities attack iron wire much more readily than copper, and iron wires have a correspondingly short life, and the corrosion of iron wires adds to their resistance. Iron wire is objectionable in long toll-lines, on account of its

* Abstract of a paper read before the Independent Telephone Association, Chicago, June 27, 1899.

weight, large ohmic resistance and the retarding effect on speech transmission of its magnetic properties.

A large use of aerial cable is to be recommended, for the reason that such cable requires small space on the pole lines, and on account of its construction is free from inductive troubles. Multiplicity of open wires is objectionable, on account of their unsightly appearance, the liability to break down from the accumulation of snow or sleet, and wind loads; also the additional length of pole required, the liability of crosses with high-tension wires, the difficulty in transposing to neutralize inductive disturbances, and the obstructions offered to firemen.

The suspension of aerial cables should be carefully done, and be made strong and secure with a large factor of safety. Great care should be exercised in testing cables at the place of manufacture, and accurate records of these tests should be preserved. Joints should be very carefully made, and none but experienced men should be permitted to make the splices. Cables should begin and end at terminal heads, so that testing and repair work can readily be done. Careful records should be made of the insulation resistance, specific inductive capacity and ohmic resistance immediately after the cables have been erected, for comparison with subsequent tests to determine if any deterioration has taken place. Such data will be found very convenient in locating faults. Cable hangers which will securely fit the cable without injury to the sheath should be used, and the spacing of these hangers should be uniform on the cable, and close enough together to prevent appreciable sag between the points of suspension. Cables should be carried on pole lines at as low point as will clear obstructions and conform to ordinances governing the stringing of wires. Substantial platforms should be securely attached to the poles at every cable terminal.

Rubber-covered wire should be used in wiring up buildings and the wiring should be concealed as much as possible. Telephones should be placed only on solid walls, where they will not be affected by vibration, where they are readily accessible and will not impede any passageway. In noisy places, or where privacy is required, sound-proof cabinets should be used. Ground wires, whether for lightning discharge or for use in a signaling circuit, should be attached to water-pipes, gas-pipes, between the meter and the main, or to ground wires driven to moist earth. Bright metallic contacts between the ground wires and ground rods should be made before the soldering is done, and the joints should be securely made. The wiring, in all cases, should conform to the requirements of the National Electrical Code. The lightning and sneak-current protection should be so placed that no dangerous currents can enter the building.

Section of switchboard should receive much intelligent care and consideration, as it is largely upon the workings of the switchboard that the character of the service depends. The very best of workmanship and materials is none too good, and the design should be as simple as possible, eliminating as far as may be the use of relays, condensers, repeating coils and other secondary apparatus. That system which requires the fewest number of movements to be made by the switchboard operator to place two subscribers in communication is the best, both on account of the rapidity of service which can be furnished and the reduction of possible mistakes on the part of the operator to a minimum. Where an exchange is to begin with more than 800 subscribers, it will be found more advantageous to use a multiple switchboard, rather than one requiring a trunking system between the operators. Supervisory signals should always be provided, which indicate to the operator if the party called for responds, and when subscribers have finished their conversation.

The switchboard should be so built that additions can be made to the ultimate capacity to which the exchange will grow without interference with any of the wiring first put in, and the distributing boards and cross-connecting boards should be erected with like provision. A complete monitor and test system should be provided, and ample provision for connecting to the toll-board, which should be put in at the same time and be wired up in connection with the main switchboard. The storage-battery and motor-generator equipment should be in duplicate. The failure to make ample provision in this respect results in frequent and vexatious interruptions to the service.

After having considered all of the electrical and mechanical features of the switchboard, and before a decision is arrived at, an opinion should be obtained from some competent patent attorney, stating that the switchboard does not infringe any good and valid patents.

The exchange should be located at the center of distribution, so that the number of feet of wire required to reach all subscribers is a minimum, provided available quarters can be secured in the locality meeting this requirement, and the rent is not prohibitory.

The switchboard room should be light, well ventilated, easily warmed and readily accessible. Sufficient space should be provided in the switchboard room for growth of the system, as it is very expensive and unsatisfactory to be compelled to change the location of the central exchange; and this is more especially so where subway is used.

Lockers, luncheon and retiring rooms should be provided for the operators, and these rooms should be bright and attractive.

The telephone instruments should be of neat and attractive appearance, with well finished woodwork and with all exposed metal parts heavily nickeled. They should be made so as to occupy as small space on the walls as possible. Bipolar receivers and granular carbon microphones will generally give more satisfactory service than other types.

Wiring of the telephones should be well done, and all joints should be soldered and all contacts so designed that oxidation or the accumulation of dust can not introduce resistance into the circuits. The automatic switches should be of the long-lever gravity type. All magnet wire should be of the best quality copper wire, covered with a hard, close winding of silk. The calling device should be positive and reliable in its operation, and that device which will require the least exertion on the part of the subscriber to call the central exchange is the most desirable. In any event, the clearing-out signal should be automatically operated by replacing the receiver on the hook. Experience has shown that many of the subscribers will not ring off when conversation is finished, and unless an automatic device is used, the operators will have to listen in constantly to ascertain if the lines are in use. This requires more operators to care for a given number of lines than with an automatic clearing-out signal, and unless the operators constantly watch the lines, they will test busy, or appear to be in service when not actually in use.

Special magnet steel should be used for all permanent magnets, as much annoyance and poor service is traceable to the use of cheap and inferior magnet steel. Receivers should preferably be made so that they can not get out of adjustment, and when this is not done, provision should be made for rapidly and accurately making the adjustment.

Receivers and the mouthpiece of transmitter should be of the best quality of hard rubber. The iron, brass, German silver, hard rubber, wire, cables and all other parts used in the manufacture of telephones and switchboards should be of the very best quality, and should be particularly suitable for the purpose for which they are to be used.

Batteries to be used with subscribers' telephones should be of the best grade open-circuit batteries, with a low internal resistance, quick recuperative power, large amperage on short circuit, and with a high voltage. On very busy lines closed-circuit batteries should be used.

Each subscriber's line, and each line as it enters into the central exchange should be protected with some device which will effectually bar the entrance into the buildings or the switchboard of destructive currents, and secure immunity to persons and property from lightning discharges, or the crossing of telephone wires with wires carrying currents of high voltage. As a rule, protection can best be obtained by a suitable combination of heating coils and carbon plates, so arranged that sneak currents will operate upon the heating coils and ground the line wires, which should be provided with fuses outside of the building that will blow with a current of not to exceed four amperes.

Detailed instructions should be prepared, covering every class of work, and these instructions should be full, clear and precise, and the work should be supervised with sufficient care to see that it is performed as set forth in the instructions. Specifications should be written, covering every class of material which is used, which should be sufficiently detailed to cover every essential point, and inspection should be made to see that these requirements are fulfilled. It will generally be found that money paid for inspection is most judiciously expended.

It will usually be found advantageous to purchase complete switchboard and telephone instruments in preference to purchasing parts, and each telephone company assembling its own apparatus. The established manufacturers have special facilities and trained men, and can turn out better work at as low a price as it will cost to do inferior work.

As in all other construction, careful preliminary studies and estimates should be made. The work should be divided into different departments with a capable and responsible man in charge of each. Rate of progress should be established so that work of different departments will all be completed at about the same time.

Materials should be purchased on competitive bids, based on detailed specifications, and should be critically inspected before being used. When quantities are large enough to warrant traveling expense, inspection at the point of manufacture will be found advantageous.

In general, essentials of good telephone service are reliability, accuracy and rapidity. Reliability can only be secured by placing all parts of the equipment as far as possible out of the reach of disturbing causes, and this is best done by a comprehensive subway system and an aerial cable system of distribution, with concealed wiring in buildings where telephones are located.

Rapidity and accuracy can best be secured by use of automatic devices of tested merit to as large an extent as possible, and by having a minimum number of contracts to be made before connection between two subscribers is effected.

ELEMENTS OF DESIGN FAVORABLE TO SPEED REGULATION IN PLANTS DRIVEN BY WATER-POWER.*

BY DR. ALLAN V. GARRATT.

(Concluded from page 75.)

If the water-wheel is likely to be subjected to large load variations, it is very desirable that the draft tube should have a much less vertical height, for the following reason:

At the bottom of a 25-foot vertical draft tube the atmospheric pressure is forcing the water up with a pressure of 14.7 pounds per square inch, and the weight of the water is pressing down with a pressure of 10.75 pounds per square inch; that is, the difference between the air pressure and the weight is $14.7 - 10.75 = 3.87$ pounds per square inch. Now, if the water velocity in the draft tube is suddenly arrested by shutting the water-wheel gates, the kinetic energy of the slowing water column will be found in the downward momentum of the water. This may easily create a downward pressure greater than 3.87 pounds per square inch, in which case a vacuum would be formed in the upper part of the draft tube and the column of water would sink in the draft tube and immediately after would rush upward again striking the bottom of the wheel with great violence. If we were so fortunate as to escape an accident of the kind above described we should find that with a draft tube of considerable height there is a tendency for air to leak in, and this, under the negative pressure of the weight of the water, expands into a partial vacuum, so that the draft tube will be only partly filled with water, and as the position of the water-wheel gates varies as the load changes, the water column in the draft tube will sway up and down, producing the effect of a pulsating head on the water-wheel. This is very detrimental to good speed regulation, and is a very common annoyance encounterd in practice. The performance of such a draft tube may be easily illustrated by holding a mercurial barometer in the hand and slowly moving it up and down.

Air chambers on flumes, to give protection against water hammer effects, are of very little practical use unless of ample size, even if they are full of air. The writer examined a plant so located that the bursting of the flume would have destroyed the whole plant and ruined an investment of at least $100,000. At the lower end of the flume was a large air chamber. The superintendent in charge pointed with pride to it, and confidently expressed the belief that it afforded ample protection against the dangerous strains on the flume, due to water hammer. Upon examining the air chamber it was found to be entirely filled with water, and it had probably been in that condition for a considerable length of time. Water, under pressure, absorbs air with great facility. An air chamber should be provided with an air-pump, which may be readily connected to some convenient source of power, and with a gauge glass to show the water level. When so arranged, and if of ample size, it affords considerable safety against pressure developed when load goes off suddenly, but it is of no practical use as an aid to the governor in maintaining constant speed.

Aside from designing the water column along the lines already suggested, so that the water may gain its working velocity in the least possible time, and also so that it may add to or take from the water-wheel the least amount of the kinetic energy of the water, the next most important thing is the design of the water-wheel gates and the method of connecting them to the governor.

As has already been pointed out, the gates are of necessity large and heavy, and yet they must be moved with great promptness and precision. The writer has had occasion to investigate with more or less accuracy the number of foot-pounds necessary to open and close the gates of several hundred water-wheels, and the surprisingly large variation in the amount of energy required leads him inevitably to the conclusion that this matter has not received, in many cases, the careful engineering treatment which it deserves.

Water-wheels are of many designs and sizes, and work under many different conditions of head, but there would seem to be no adequate reason why the gate of one water-wheel developing a certain amount of power under a given head should require only 1,000 foot-pounds to completely open it, and the gate of another water-wheel of different make, developing the same amount of power under the same head, should require 60,000 foot-pounds. Yet such has been found to be the case. The above example, taken from actual practice, is by no means unusual; and scores of such cases could be cited showing relatively absurd figures.

Some builders prefer to use cylinder gates on their wheels; others prefer wicket gates; while still others adhere to register gates. It is not the intention of this paper to enter into a critical comparison of the merits of these various types of gate, and, in fact, from the standpoint of speed regulation, no such comparison is necessary for the good and sufficient reason that there are wheels on the market of all three of the above kinds which show little to be desired in the ease with which the gates may be moved. It is also true that there are makes of wheels of all three kinds which can not be governed accurately under variable loads, simply for the reason that their gates can not be moved quickly enough.

It is often necessary to start a gate from a rest and completely open or close it in two or three seconds, or give it a proportionately smaller motion in a proportionately shorter space of time. Or, what is still more severe, it is often necessary that while a gate is opening or closing, its motion be instantly stopped and reversed.

If one will watch a thoroughly first-class governor handling the gates of a water-wheel which is driving an electric generator operating on a variable load, one is convinced of the fact that the governor has to develop considerable amounts of energy in surprisingly short spaces of time, and that the rigging connecting the governor and the gates is subjected necessarily to considerable strain, from which it follows that the easier the gates move the less chance there is of stripping gears and twisting off shafts; to say nothing of relieving the governor itself of unnecessary strain.

All gears between governor and gate—except immersed racks and pinions—should be cut, of first class workmanship and not too large for the work required of them. The latter precaution is necessary to prevent the MV^2 energy in the gears themselves destroying the rigging when the direction of motion is suddenly reversed. Shafts should be of just sufficient size to give an ample factor of safety, and prevent torsional difficulties, for it is absolutely necessary that the smallest amount of motion of the governor shall be transmitted accurately to the water-wheel gate. Lost motion in gears and twisting of shafts are fatal to good regulation. Hand-wheels should be so arranged that they may be entirely thrown out of connection with the rigging while the governor is in action, or they may be unkeyed in some simple manner.

Counterbalancing a gate is not the equivalent of having it in water balance. All vertical cylinder gates are necessarily out of balance to an amount equal to their immersed weight, but that is usually so small that it is not necessary to counteract it with a counterweight.

Some designs of gate show a violent tendency to close or stay closed. It is the custom to counterbalance such gates, and this practice leads to endless trouble on account of the kinetic energy in the counterweight. It being often necessary to reverse the motion of the counterweight suddenly, the kinetic energy expended at the moment of reversal is often sufficient to wreck the rigging. If counterweights must be used, it should be remembered that their kinetic energy is proportional to their weight, but also proportional to the square of their velocities; from which it follows that a heavy, slow-moving weight does less damage than a light, rapid-moving one.

Some general statements may be made in regard to the design of water-wheel gates adapted to plants, in which it is desirable to obtain good speed regulation.

It has been the custom of late to cast onto cylinder gates fingers reaching out between the guides. These innocent looking devices, which are supposed to guide the water into the wheel properly, and hence raise its efficiency, are a source of no end of trouble when it comes to moving the gate quickly enough to produce good speed regulation. The direction of motion of the water as it enters the wheel is always such that it presses these fingers downward with tremendous force, giving the gate a strong tendency to close. By removing these fingers, the amount of energy necessary to open the gates can always be reduced by at least one-half, and oftentimes more than that. There are scores of water-wheels on record which were so much out of balance, due to the fingers on the gates, that it was found impracticable to govern them satisfactorily on account of gears stripping and shafts twisting off. In the writer's experience, it has always been found practicable to govern these wheels by removing the fingers.

Now, as to the question of efficiency. The writer has often had to meet the argument of the few per

* A paper presented at the sixteenth general meeting of the American Institute of Electrical Engineers, Boston, June 27, 1899.

cent of efficiency supposed to be lost by removing these fingers, and, to answer this question, tests have been made which show that there is no material gain in the efficiency of a water-wheel set under ordinary working conditions, by attaching fingers to the gate.

Two vertical cylinder-gate wheels of the same size and make were set in open flumes side by side. The head was precisely the same in both cases. Both wheels drove electric generators of the same make, type and size. Both wheels were furnished by the maker with cylinder gates, precisely alike, and provided with fingers. It was found impracticable to govern these wheels properly, on account of the gates working so hard and being so much out of balance. The fingers were removed from the gate of one wheel, and it was at once found that the wheel governed very satisfactorily under a very variable load. Then a test was made of the efficiency of the two wheels, one with and one without fingers on the gates. Wires were brought up from the gates, carried over pulleys, kept taut by small weights, and they terminated in pointers reading on the same scale. A constant electrical load was switched onto one generator, and the position of the pointer indicating gate position was noted. Then the load was switched onto the other generator (the speed being kept the same in both cases) and it was noted that the pointer of the second unit stood at the same point at which the pointer of the first unit had previously stood. This experiment was repeatedly tried at a number of different loads, from slightly above friction load to nearly the full capacity of the wheels. So far as could be observed, the efficiency of the wheel without fingers on the gate was as good as that of the wheel with the fingers. The particular test above described was made by Mr. J. H. Wilson, in the plant of the Berlin Mills Company, Berlin Mills, N. H.

The writer is aware that this test is not the equivalent of a Holyoke test, but it is certainly of great interest to the practical engineer who is harassed by the thought that in avoiding the Scylla of bad efficiency he will surely be wrecked on the Charybdis of an ungovernable gate.

There are a number of other details of cylinder-gate construction which time and space will not permit us to touch upon here, but which should be considered by the thoughtful engineer before making a selection. The thing to be borne in mind is that the cylinder and its connections should be of such design that they may be easily moved, and will not bind and run hard in any portion of their travel.

Wicket gates also have their peculiarities. Some makers hang them in such a manner that they are practically in water balance in any position, and may be readily opened and closed with a small expenditure of energy. Such gates leave little to be desired, and wheels fitted with gates so designed may be governed with the greatest degree of exactness and without fear of injury to the rigging or governor. The writer has observed, however, that some wicket gates which move very easily have so much lost motion that in certain portions they tend to flop (no other word conveys the idea) first in one direction and then in the other, causing a pulsating speed which is very annoying and apparently inexplicable until one has investigated the cause. The danger of lost motion is greater with wicket than with cylinder gates, but with proper construction it is found in practice that lost motion may be entirely eliminated from wicket gates.

In some wicket-gate wheels the wickets are hinged at one end and attached by the other end by tangential arms to a banjo, which in turn is geared to the shaft going to the governor. Such gates are entirely out of water balance when partly closed, and the more they are closed the more they are out of balance. Wheels with gates of this description are very difficult to govern. Frequently the strength of the wickets and radial arms is not sufficient to withstand the water pressure, even if sufficient energy can be supplied to them. In recent practice a wheel of this description was found to require some 40,000 foot-pounds to open it. Another wicket-gate wheel of different make but the same rated horse-power was found to require only 5,000 foot-pounds to open it. As another recent instance, it was found that a pair of wicket-gate wheels of the kind described above required 19,000 foot-pounds to open them; another pair of different make but the same rated horse-power required but 2,500 foot-pounds to open them. The wheels compared above were working under the same head.

The way a maker proposes to rig his gate is a good indication of the amount of energy he thinks it will take to move it. If he thinks it is necessary to use worm gears or multiplying gears giving a large number of turns to the hand-wheel it is safe to conclude that in his opinion—and he certainly ought to know—the gate will move hard or be much out of balance. Such wheels it is safe to leave alone if accurate speed regulation under variable load is the end in view.

All practical engineering is a compromise between the desire of the engineer, on the one hand, to produce a perfect piece of engineering, and the unwillingness of the stockholders, on the other hand, to invest money which will not bring direct returns in the shape of dividends; or, to state the matter more conservatively, there is always a point in each plant beyond which investment must not go, and this point is different for each plant, being fixed by the economic conditions which surround the particular enterprise.

For the above reasons it is impossible to lay down hard and fast rules for the development of water-powers. Assuming that the value of all engineering is measured by the dividends earned, what would be good engineering in one case is bad engineering in another. Yet it i equally true that, in an electric plant driven by water power, the worst possible place to economize is in the channels and conduits which bring the water to and away from the water-wheels, and in the water-wheels themselves and their governors. Dollars saved here are apt to be expensive economy.

The infinite variety in which natural water-powers present themselves makes this a difficult branch of engineering, and much is yet to be learned about it. Yet, it is safe to say that enough is now known about the subject to permit almost any naturally good water-power to be so developed and utilized that the plant driven by it may be as readily controlled and its speed maintained as constant as though the driven load were carried by first-class steam engines It should, however, be remembered that no matter how well the plant is designed, good speed regulation can not be obtained unless the water-wheel governors are of correct design and well built. The value of a governor is measured by two things—the promptness and ease with which it will move the water-wheel gates to the correct position and stop them when they get there, and its ability to compensate by adjustment of the gate for the kinetic energy in the moving water column. One might add sensitiveness as a mark of a good governor, but nearly all modern governors are very sensitive, though most of them sadly lack the other two qualifications named above. The best made governors on the market will begin to move the water-wheel gates before any tachometer on the market will show a change in speed, yet they would not govern if they did not know when to stop as well as when to start.

I have been requested by a number of gentlemen to say something about flywheels. We may approach this subject in the following manner:

When we wish to find out how much energy is stored in a revolving flywheel we begin by finding its moment of inertia, which is its weight multiplied by the square of its radius of gyration.

Let J = radius of gyration in feet,
W = weight in pounds,
I = moment of inertia.

$$I = W J^2 \qquad (19)$$

The energy in foot-pounds stored in the revolving wheel is as follows:

Let
$\mathcal{E}$ = energy stored in the wheel.
a = angular velocity in radians per second $= \frac{2 n \pi}{60}$ (20)

where
n = revolutions per minute
and
$\pi = 3.14159$

Then

$$\mathcal{E} = \frac{I a^2}{2} \qquad (21)$$

Substituting the value of a we get

$$\mathcal{E} = \frac{I \left(\frac{2 n \pi}{60}\right)^2}{2} \qquad (22)$$

Evolving which we get

$$\mathcal{E} = \frac{I n^2 \pi^2}{1800} \qquad (23)$$

Which is the form in which the formula is ordinarily used.

It may be simplified for

$\frac{\pi^2}{1800} = .00548$ is a constant.

Substituting this we get (24)

$$\mathcal{E} = I n^2 \times .00548$$

But you will note that this expression may be conveniently divided into two parts, as follows:

$$\mathcal{E} = n^2 \times (I \times .00548) \qquad (25)$$

Which is equivalent to saying that every flywheel possesses a certain quantity, which, multiplied by the square of its revolutions per minute, equals the foot-pounds of energy stored in it. This quantity is its $(I \times .00548)$, which we may symbolize by $\mathcal{K}$, and we may write

$$\mathcal{E} = n^2 \mathcal{K} \qquad (26)$$

Or, substituting our value of I, we may write

$$\mathcal{E} = n^2 (W \times J^2 \times .00548) \qquad (27)$$

It is evident that this value of $\mathcal{K}$, which is the energy stored in the wheel when making one revolution per minute, when once found for any particular flywheel, may be used at once to calculate its energy at any speed, simply by multiplying it by the square of its revolutions per minute.

This value of $\mathcal{K}$ for the rim of any flywheel may be found as follows:

Let
w = weight in pounds of one cubic foot of the metal of which it is made.
d = outside diameter of rim in feet.
d_1 = inside diameter of rim in feet.
ℓ = face of rim in feet.
Then

$$\mathcal{M} = \frac{w\,\ell\,(d^4 - d_1{}^4)}{59{,}814} \qquad (28)$$

But a close enough approximation to the $\mathcal{M}$ of a cast-iron flywheel of usual shape, with light arms, may be found as follows:
Let
W = weight of wheel in pounds.
d = mean diameter of rim.
Then

$$\mathcal{M} = \frac{W\,d^2}{23{,}000} \qquad (29)$$

Now, the question is, how much of a flywheel do we require in any particular case. Let us return to wheel No. 1 in Fig. 4.

We remember that when the gate of this wheel was suddenly opened wide it was .7 second before the water was doing its full amount of work on the runner. We must also remember that the curve 0 — 1 (see Fig. 7) with which the water got up to full power was a parabola. The area outside the parabolic line was the work which the water did do in this .7 second, and the area inside this parabolic line was the work which the water failed to do in the same time. From the law of areas of parabolas it follows that the area inside this curve (which is a half parabola) is two-thirds of the area of the rectangle enclosing the curve. Or we may say more simply that while the wheel was getting up to speed it performed one-third of the work which it would have done in the same time had it been working at full gate and full speed.

Let us begin to apply this to the design of a suitable flywheel. Assume, for simplicity of calculation, that the water-wheel is about 48 inches in diameter and at full gate develops 100 horse-power and runs at 75 revolutions per minute. Let us also assume that it must not, upon the whole load being instantly thrown on or off, run more than four per cent below or above normal. Its minimum speed must be then

$$75 - \frac{75\times 4}{100} = 72 \text{ R.P.M.}$$

and its maximum speed must be

$$75 - \frac{75\times 4}{100} = 78 \text{ R.P.M.}$$

We must also remember that it was found that we could not completely open the gates in less than two seconds. Therefore, supposing that the rate of opening the gate was uniform, the average gate opening during the two seconds was only one-half, and if the wheel during every instant of time had been developing the full power due to the instantaneous value of gate opening it would have developed only one-half as many foot-pounds as though it had been at full gate for two seconds. But we found that the power lagged .7 second behind the gate opening, during which time it developed only one-third of the power due to the gate opening; hence, for two seconds the wheel developed one-third of one-half the power it would have developed during the same time at full gate, and for .7 second more it developed one-third of full power. Reducing this to foot-pounds we have

$$\frac{100 \times 550 \times 2}{6} = 18{,}333 \text{ foot-pounds.}$$

$$\frac{100 \times 550 \times .7}{3} = 12{,}833 \text{ foot-pounds.}$$

Adding these we get 31,166 foot-pounds, which is the total energy developed by the water-wheel in 2.7 seconds.

If working at full gate and maximum flume velocity for that length of time it would have developed

$$100 \times 55 \times 2.7 = 110{,}000 \text{ foot-pounds.}$$

Subtracting from this 31,166 foot-pounds,

We get 78,834 foot-pounds,

which is the amount of energy which must be developed by the flywheel before its speed is reduced to 72 revolutions per minute.

Let us assume that the flywheel makes the same number of revolutions as the water-wheel.

Its energy at 75 revolutions per minute is

$$\mathcal{M} \times 75^2 = \mathcal{M} \times 5{,}625$$

Its energy at 72 revolutions per minute is

$$\mathcal{M} \times 72^2 = \mathcal{M} \times 5{,}184$$

Subtracting one from the other we get 441

The value of $\mathcal{M}$ is therefore

$$\mathcal{M} = \frac{78{,}834}{441} = 178$$

From the above value of $\mathcal{M}$ should be deducted the $\mathcal{M}$ of the water-wheel itself and the other rotating parts, such as pulleys and armatures. For simplicity of calculation I shall not make this deduction in this case, and we will proceed to design a flywheel of suitable proportions, which shall have an $\mathcal{M}$ value numerically equal to 178.

As it is to be of cast-iron we will limit its peripheral speed to 65 feet per second.

Let d = its outside diameter in feet.
p = its peripheral speed in feet per second.
R = revolutions per minute.
Then $d = \dfrac{p \times 60}{R\,\pi}$

Applying numerical values we get

$$d = \frac{65 \times 60}{78 \times 3.14} = 15.5 +$$

Assume d_1 or the diameter inside the rim = 14.5 feet.

Transpose formula No. 28 so as to get ℓ or the face of the wheel in feet.

$$\ell = \frac{\mathcal{M} \times 59{,}814}{w \times (d^4 - d_1{}^4)} \qquad (30)$$

Applying numerical values we get

$$\ell = \frac{178 \times 59{,}814}{450 \times (15.5^4 - 14.5_4)} = 1.6 \text{ feet}$$

= 1 foot 7 inches nearly.

Our flywheel rim is, therefore, 15 feet 6 inches outside diameter, six inches thick and one foot seven inches wide on the face, and would weigh 16,992 pounds.

This strikes one as a very large flywheel for a 100-horse-power unit, but it must be remembered that it is intended to perform very severe duty. Moreover, no allowance has been made for the kinetic energy in the flywheel arms, nor in the water-wheel itself, and other rotating parts. All of these corrections should be made and the proper deduction made from the flywheel above designed.

Another correction should also be made which would still further reduce the size of the flywheel.

It was assumed that the water-wheel was working at normal speed and friction load when the whole load was thrown on. Friction load is a part of whole load, and hence when we say we throw on whole load, we really mean that we are throwing on something less than 100 horse-power. Also at friction load the water in the flume had some velocity, and hence we did not have to start the water from a condition of rest, but from a condition of slow velocity.

To make all these corrections involves a considerable knowledge of hydraulics and mechanics. To treat this subject in a complete manner, would involve a good many figures, and would extend this paper far beyond proper limits.

It may be noted here that if it is found desirable to change the value of $\mathcal{M}$ of a flywheel after it is designed, it is not necessary to redesign the wheel. The dimensions of flywheels are as the fifth roots of their $\mathcal{M}$'s. We have found a flywheel whose $\mathcal{M} = 178$. If we now wish to reduce its $\mathcal{M}$ to 150, we write

$$\sqrt[5]{178} : \sqrt[5]{150} = 15.5 : \text{diameter}$$

From which we get

$$\text{diameter} = \frac{\sqrt[5]{150} \times 15.5}{\sqrt[5]{178}} = 15.0 \text{ feet.}$$

or formularizing it we get

$$D_1 = \frac{\sqrt[5]{\mathcal{M}_1} \times D}{\sqrt[5]{\mathcal{M}}}$$

Where
D = diameter of wheel having given $\mathcal{M}$
D = diameter of required wheel
$\mathcal{M}$ = given value of $\mathcal{M}$
$\mathcal{M}_1$ = required value of $\mathcal{M}$.

All of the linear dimensions should be treated in the same way. For example: If we have a design of a flywheel drawn to a scale of one inch to the foot, and in building the wheel we read the drawing as though it were one-half inch to the foot, then the $\mathcal{M}$ of the flywheel will be $2^5 = 32$ times as large as it would have been if the wheel had been built according to the scale of one inch to the foot.

Where we have a flywheel of a given $\mathcal{M}$ and we know how many foot-pounds it will be required to give up or absorb, as the case may be, we may find the resulting speed by the following formula:

$$r = \sqrt{\frac{\mathcal{E} - \mathcal{E}_1}{\mathcal{M}}} \qquad (32)$$

where r = the final revolutions per minute.
$\mathcal{E}$ = energy in foot-pounds stored in wheel at normal speed.
$\mathcal{E}_1$ = energy in foot-pounds required of the wheel.
$\mathcal{M}$ = energy in wheel when making one revolution per minute.

The above formula may be more conveniently as follows:

$$r = \sqrt{\frac{(\mathcal{M} \times R^2) - \mathcal{E}_1}{\mathcal{M}}} \qquad (33)$$

where R = normal revolutions per minute. Applying to the wheel we have been discussing we have

$$r = \sqrt{\frac{(178. \times 75^2) - 78{,}834}{178.}} = 72$$

which is the minimum revolutions per minute which we first agreed upon.

We have seen that to make even an approximate design of flywheel we have required considerable data to work from, and have been obliged to do quite a little figuring, and yet the water-wheel in question was set in the simplest possible manner. Had it been set in a closed flume like wheel No. 2, Fig. 4, the problem would have been greatly complicated.

In view of these facts, it becomes quite amusing to note the alleged accuracy with which statements are often made in regard to the exact amount of flywheel which is required to give stated degrees of speed regulation upon 10, 25, 50 per cent, etc., of the load being instantly thrown off or on, when it is perfectly evident that only part of the data is available which would enable only approximate figures to be made.

The one concluding crumb of comfort which the writer is able to offer is found in the fact that in a very large practice, he has never found it necessary with a water-wheel set in an open flume, to install a flywheel in order to obtain a perfectly satisfactory speed regulation under any operating conditions of an electric plant. The various rotating parts of the plant, such as water-wheels, armatures, pulleys, etc., having sufficient moment of inertia and angular velocity to enable a first-class governor to hold the speed within very satisfactory limits under any sudden load changes which occur in the actual operation of the plant.

If the design of the hydraulic part of the plant is bad, it is wiser to try and improve it, rather than lean largely on flywheel effect, which is a weak prop at the best.

ADVANCE INFORMATION

New Telephone and Telegraph Companies.

EASTON, PA.—The United States Long-Distance Telephone Company has been incorporated; capital, $1,000; incorporators, H. Mutchler, E. W. Evans, S. S. Yohe, J. Young, G. F. Coffin, all of Easton.

COLUMBUS, OHIO—The Franklin Telephone Company of Columbus has been incorporated with $50,000 capital stock. The company will operate telephone lines in Franklin County. The incorporators are F. A. Davis, H. D. Critchfield, J. M. Thomas, Cyrus Huling and R. E. Sones, all of whom are interested in the new Citizens' Telephone Company, of this city.

HALLSBORO, R. I.—The Chesterfield & Powhatan Telephone Company has been incorporated; capital, $5,000; incorporators, W. W. Baker, B. T. Watkins, of Hallsboro; Dr. J. B. Fisher, W. P. Field, of Midlothian; A. L. Adamson, of Bon Air; R. A. Justis, L. P. Hill, of Dry Bridge; M. A. Cogbill, P. V. Cogbill, of Chesterfield.

STURGEON, MO.—The Sturgeon Leader Telephone Company is putting in local exchanges in Sturgeon and Clark, and building lines to Riggs, Rileysburg, Rucker, Harrisburg, Middle Grove and Saling.

SALISBURY, N. H.—The Kearsarge Telephone Company has been incorporated; capital, $2,300; incorporators, W. H. Burbank, H. Dodge, Webster; I. W. Little, T. D. Little, Salisbury; A. A. Beaton, Webster.

WARREN, OHIO—The Jefferson & Warren Telephone Company have agreed to build a connecting line, and in a few weeks Warren, Jefferson, Ashtabula and other northern towns will have connection with Sharon, Greenville and New Castle in Pennsylvania. The lines will connect at Sharpsville, Pa., and to reach that point the Jefferson & Warren Company will build a line from Kinsman.

COLUMBUS, OHIO—The National Telephone Company has been incorporated to construct and operate a telephone exchange; capital, $10,000; incorporators, P. H. Bruck, W. J. Dusenbury, J. J. Dun, G. W. Dun, L. P. Stephens.

TOMBEAN, TEX.—The Tombean & Sherman Telephone Company has been incorporated; capital stock, $1,200. Purpose, to own, maintain and operate a telephone line between Tombean and Sherman. Incorporators, J. Hughes, J. Baxter, W. R. Brents, and others.

DANIELSVILLE, GA.—The Danielsville & Comer Telephone Company has been incorporated. Directors, W. C. Buchanan, E. L. Alexander, of Comer; L. E. Greene, Berry J. Moseley and David W. Meadow, of Danielsville. W. C. Buchanan, president and general manager; L. E. Greene, vice-president; Berry J. Moseley, secretary and treasurer.

New Electric Railways.

ANGORA, PA.—The Delaware County & Philadelphia Electric Railway Company, operating the trolley road from this place to Media, is soon to begin the extension of the road out the Baltimore pike to the Black Horse, and then to Glen Riddle, Rockdale and Lenni.

NEEDHAM, MASS.—The Medfield & Needham Street Railway Company has been formed, to operate a line of electric street cars between this place, Charles River village, Dover and Medfield.

ALBANY, N. Y.—The Mexican Mineral Railway Company, with a capital stock of $350,000, has been incorporated, to operate railroads now built, or to be built in Mexico from Monterey and San Pedro. Directors include George D. Cook, Chicago; William F. Gillespie, Robert S. Towne, Charles J. Norse, Jr., Edward M. Shepard, New York. Principal office, New York.

ALBANY, N. Y.—The Staten Island Rapid Transit Railway Company has been incorporated; capital, $1,500,000. Directors include J. Frank Emmons, J. Vansmith, James M. Davis, O. S. Weed, Norman Hall, Louis L. Stanton. The company is the purchaser of the old company's franchise and property.

COLLEGEVILLE, PA.—The Trappe & Limerick Street Railway Company has been incorporated; capital, $20,000; incorporators, H. T. Hunsicker, Iron Bridge; A. H. Hunsicker, Collegeville; E. G. Brounback, Trappe; S. B. Horning, Lower Providence; G. W. Zimmerman, Collegeville.

HARRISBURG, PA—Nearly all the necessary rights of way have been secured for a trolley line from Progress to Linglestown, the completion of which will connect the latter place with Harrisburg by electric railway. The new line will be capitalized at $30,000.

DETROIT, MICH.—The Port Huron & Port Austin Electric Railway Company has been incorporated to construct and operate street railways; capital, $25,000; incorporators, M. A. McCarron, F. H. Cranford, Detroit; F. T. Sinclair, Port Austin.

LAPORTE, IND—A Pittsburgh syndicate made application to the City Council for a franchise for the building of an electric railway between this city and Michigan City.

BOSTON, MASS.—The Hanover Street Railway Company has changed its name to South Shore & Boston Street Railway Company. This road is a consolidation of the Rockland & Abington, the Braintree & Weymouth, the Bridgewater, Whitman & Rockland, the Hingham, and the Hanover street railways. The capital stock of the consolidated company is $690,000.

WHITE HILL, N. J.—The Monmouth Traction Company's trolley road will soon be extended from this place to Riverton.

New Incorporations.

TRENTON, N. J.—The American Switch Company has been incorporated; capital stock, $11,000,000. The company will manufacture switches and other railroad appliances. The incorporators are William A. Doyle, of Chicago, and Edward Shearson and Benjamin C. Van Dyke, of New York.

JERSEY CITY, N. J.—The Beacon Contracting and Construction Company has been incorporated to construct gasworks, electric light plants, etc.; capital, $125,000; incorporators, Leslie J. Montgomery, William S. Gale, Henry K. Landis, Henry F. Lydecker.

HARVEY CEDARS, N. J.—The Interstate Development and Construction Company has been incorporated to construct and operate water, steam, gas and electric plants; capital, $5,000; incorporators, Francis Fennimore, Harvey Cedars, N. J.; Wm. H. Sayer, Wayne, Pa.; Edward P. Vogels, Philadelphia, Pa.

PORTLAND, ME.—The Massachusetts Manufacturing Company has been incorporated to manufacture electrical appliances; capital, $25,000; incorporators, E. A. Hall, W. A. Nutting, O. B. Johnson, J. A. Saunders, W. J. C. Semple, of Boston; J. H. Drummond, Jr., and C. M. Drummond, of Portland.

BROOKLYN, N. Y.—The G. B. Cornell Company has been incorporated to manufacture electrical machinery and supplies; capital, $5,000; incorporators, G. B. Cornell, of Montclair; J. Huber and O. Huber, of Brooklyn.

LOS ANGELES, CAL.—The Electric Supply and Fixture Company has been incorporated; capital stock, $25,000. The directors are M. Y. Kellam, A. W. Brode, James North, Robert Gaylord and Thomas Foulkes.

NEW YORK, N. Y.—The R. Momand Electric Company has been incorporated; capital stock, $500,000.

SAN FRANCISCO, CAL.—The Napa Gas and Electric Company has been incorporated to manufacture and sell gas and electricity; capital, $100,000; incorporators, T. Addison, of Berkeley; J. L. Howard, of Oakland; O. E. Clark, of Napa; S. E. Keaney, of San Francisco; J. G. Whittengton, of Alameda.

SAN FRANCISCO, CAL.—The Union Gas Light Company has been incorporated to manufacture and sell gas and electricity; capital, $1,000,000; incorporators, I. M. Bowen, M. B. Bowers, J. H. McCarthy, J. M. Kinley, A. M. Armstrong, all of San Francisco.

KITTERY, ME.—The Hatch Accumulator Company has been incorporated for the purpose of manufacturing and dealing in electrical supplies, with $1,000,000 capital stock. The officers are: president, George E. Hatch, of Quincy, Mass.; treasurer, Joseph Middleby, Jr., of Malden, Mass.

CHEYENNE, WYO.—The American District Telegraph Company has been incorporated to construct and operate telegraph lines; capital, $20,000; incorporators, A. W. Barber, J. D. Freeborn, T. F. Burke, all of Cheyenne.

Electric Light and Power.

CLIFTON, PA.—The Citizens' Electric Light and Power Company has been awarded the contract to light the borough of Lansdowne for five years.

ELWOOD, IND.—The Elwood Electric Light Company has been incorporated, with a capital stock of $80,000, for the purpose of supplying the city of Elwood with electric light and power for public and private consumption.

SHREVE, OHIO—The Shreve Electric Light and Power Company has been incorporated to furnish light and heat; capital, $8,000; incorporators, E. K. Gardner, L. M. Gardner, H. J. Good, C. M. Gardner.

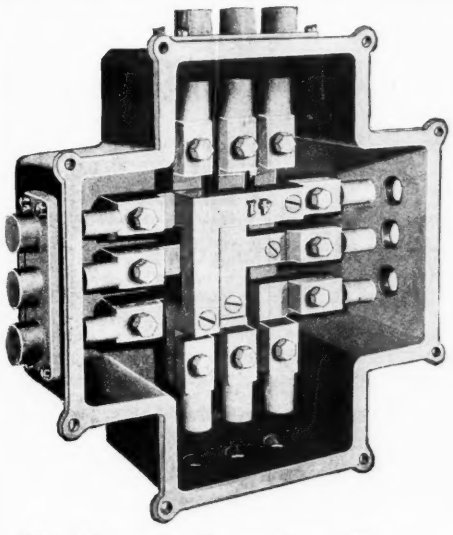
BLOOMINGTON, ILL.—A corporation, known as the Bloomington Gas Light and Electric Company, has been formed by the consolidation of the Citizens' Gas Light and Heating Company, the Citizens' Electric Company and the Gridley Gas Works; the capital stock is $400,000. This unites all the lighting plants of Bloomington, with the exception of the Bloomington Electric Company.

TUXEDO, N. Y.—The Tuxedo Electric Light Company has been incorporated, with a capital of $80,000. The directors include Pierre Lorillard, Jr., Richmond Talbot, George Griswold and Charles S. Patterson, of Tuxedo Park, and W. P. Homans, of New York city.

KNOXVILLE, TENN.—The City Council has granted a franchise and right-of-way to the Knoxville Water and Electric Power Company for building and operating a plant for lighting and heating purposes. The plant will be located a few miles up the Tennessee River.

WILLIAMSPORT, PA.—P. B. Shaw, of this city, has purchased the Harrisburg Electric Company's interest in that city and has organized a new company with a capital stock of $2,000,000. E. Z. Wallower, president; secretary and treasurer, Mr. Stone, and Mr. Shaw is one of the directors. The Harrisburg plant is one of the most successful of the kind in the state outside of the larger cities. It furnishes light for the city, has a big commercial lighting business and furnishes considerable power. The new company will increase the capacity of the plant fifty per cent, and will put in the latest direct-connected apparatus.

HAWLEY, PA.—The Hawley Electric Light and Power Company, of which ex Mayor Connell, of this city, is president, has decided to extend its lines to White Mills, a distance of five miles from Hawley. Shepherd & Rust, electrical contractors, of Wilkesbarre, have been awarded the contract to extend the wires.



Tailleur Service Box.

An Interesting Bulletin, Serial Number 35, Descriptive of our Underground Material will be mailed on application.

G.I. Underground Material.

TRADE MARK.

GENERAL INCANDESCENT ARC LIGHT COMPANY,

Arc Lamps, Incandescent Lamps, Switches, Switch Boards and Panel Boards, Attaching Plugs with Flush Receptacles, Other Central Station Specialties of the Highest Grade.

GENERAL OFFICES AND FACTORY:
572-578 FIRST AVENUE, CORNER THIRTY-THIRD STREET, NEW YORK.

BRANCH OFFICES:

NEW YORK, 39-41 Cortlandt St. — BOSTON, 31 Milk St. — PHILADELPHIA, 233 Drexel Building. — CLEVELAND, 39-47 E. Prospect St. — SAN FRANCISCO, 598 Parrott Building.
E. A. Brooke Ridley.

CHARLOTTE, N. C.
29½ South Tryon Street

MARTIN J. INSULL CO.:

CHICAGO, 1012-13 Monadnock Block. — ST. LOUIS, 511 Security Building. — MINNEAPOLIS, 616 Guaranty Building. — MILWAUKEE, 700 Pabst Building.

THE CROCKER-WHEELER COMPANY, AMPERE, N. J.

Manufacturers and Electrical Engineers

OF GENERATING AND DRIVING APPARATUS IN STANDARD AND SPECIAL FORMS.

FOR LIGHTING, POWER, TRANSFORMING VOLTAGE AND SPECIAL APPLICATION TO MACHINERY.

Send for our Illustrated Catalogues, or write for specific information to our

General Offices: 39 Cortlandt St., New York. Branches: Philadelphia, Chicago, and Boston.

VALUABLE ELECTRICAL BOOKS.

ELECTRIC LIGHT AND POWER.

Allsop's "Practical Electric Light Fitting;" a treatise on electric light wiring and fitting. Price..... $1 50
Noll's "How to Wire Buildings." Price..... 1 50
Crocker-Wheeler's "Practical Management of Dynamos and Motors;" description and directions. Price..... 1 00
Buckley's "Electric Lighting Plants;" cost and operation. Price, 2 00
Crocker's "Electric Lighting;" for the use of electricians, students and others interested in the installation or operation of electric lighting plants. Price..... 3 00
Latimer's "Incandescent Electric Lighting;" a practical description of the Edison system. Price..... 50
Unwin's "Development and Transmission of Power from Central Stations;" a new and timely book. Price..... 3 50
Bell's "Electric Power Transmission;" a practical treatise for practical men. Price..... 2 50
Atkinson's "Elements of Electric Lighting." Price..... 1 50

ELECTRIC RAILWAY.

Perry's "Electric Railway Motors;" their construction, operation and maintenance. Price..... 1 00
Merrill's "Reference Book of Tables and Formulas for Electric Street Railway Engineers." Price..... 1 00
Trevert's "Electric Railway Engineering;" embracing practical hints upon power-house, dynamo, motor and line construction; for the use of students. Price..... 2 00

TELEPHONE.

Allsop's "Telephones: Their Construction and Fitting." Price..... 2 00
Hopkins's "Telephone Lines and Their Properties;" design and construction of city lines. Price..... 1 50
Poole's "Practical Telephone Hand-Book." New edition. Price... 1 50
Webb's "Telephone Hand-Book." Price..... 1 00
Haskins's "Telephone Troubles and how to Find Them;" a complete hand-book for telephone inspectors. Price..... 25
Bennett's "Telephone Systems of Europe;" new and very complete. Price..... 4 50
Preece & Stubb's "Manual of Telephony." Price..... 4 50
Houston & Kennelly's "Electric Telephony." Price..... 1 00
Cary's "How to Make and Use the Telephone." Price..... 1 00

X RAY.

Meadowcroft's "A B C of the X Rays." Price..... 75
Thompson's "Roentgen Rays and Phenomena of the Anode and Cathode." Price..... 1 50
Morton & Hammer's "The X Ray, or Photography of the Invisible." Price..... 50
Trevert's "Something about X Rays for Everybody." Price..... 25
Norrie's "Ruhmkorff Induction Coils." Price..... 50

MISCELLANEOUS.

Cushing's "Standard Wiring." Price..... 1 00
Thomson's "Dynamo Electric Machinery." Price..... 6 00
Meadowcroft's "A B C of Electricity." Price..... 50
Tesla's "Experiments with Alternate Currents of High Potential and High Frequency"—A Lecture with biographical sketch. Price. 1 00
Edison's "Life and Inventions;" by W. K. L. and A. Dickson. Price..... 4 50
Trevert's "How to Build Dynamo Machinery." Price..... 2 50
Parkhurst's "Electric Motor Construction for Amateurs." Price... 1 00
Benjamin's "Age of Electricity—From Amber-soul to Telephone." Price..... 2 00
Foster's "Central Station Bookkeeping." Price..... 2 50
Houston's "Dictionary of Electrical Words, Terms and Phrases." Price..... 5 00
Replogle's "Electricity and Water-Power." New. Price..... 1 00
Ayrton's "Practical Electricity;" for first year students of electrical engineering. New. Price..... 2 50
Grier's "Note-Book of Wiring Tables;" How they are made, and how to use them. Price..... 1 00
Hawkin's "New Catechism of Electricity." Price..... 2 00

All of these books sent prepaid on receipt of price. Address

ELECTRICAL REVIEW PUBLISHING CO.,

P. O. Box 2339. 41 PARK ROW, NEW YORK.

PATENTS TRADE-MARKS COPYRIGHTS

EDWARD S. DUVALL,
Solicitor of Patents,

Counsellor in Patent Causes.

Some time connected with the late Benjamin Butterworth, before he retired from practice to assume the office of Commissioner of Patents.

Prompt attention given to all matters before the Patent Office, and applications for patents prepared here at Washington from sketches, photos, or models, in a manner to give highest satisfaction and with less expense than you will incur elsewhere. Write and convince yourself of this fact. As an attorney at Washington is indispensable you can save the expense of having two by communicating directly with me.

LOAN AND TRUST BUILDING,
WASHINGTON, D. C.

YOU CAN GET A PATENT
For any invention. Send me particulars and a rough sketch for advice, free by return mail.

IMPORTANT to have your attorney at Washington, saving time and expense.

HENRY S. THORNBERRY, Patent Solicitor,
1427 F STREET, N. W., WASHINGTON, D. C.

The STEWART

Combination Socket Handle and Adjuster.

METAL FERRULE.

It speaks for itself. Send for Sample. Takes all strain from the socket connections.

FRANK H. STEWART & CO.
7th and Filbert Sts., Philadelphia, Pa.

JUST WHAT YOU NEED
The Incandescent
ELECTRIC LIGHT MANIPULATOR

For cleaning and renewing Incandescent Lights situated in high places. Made to fit any candle-power bulb of any standard make.

JUST WHAT IS NEEDED for Hotels, Depots, Halls, Theatres, Public Buildings, Street Lights, Stores, Fine Residences, Etc.

Send for description and prices.

MANUFACTURED AND FOR SALE BY
Incandescent Electric Light Manipulator Co.
Room 800
116 Bedford St. BOSTON, MASS.

DESIGNERS AND ENGRAVERS
BY ALL METHODS
Electrical Machinery and Apparatus
A SPECIALTY
GET OUR PRICES AND SPECIMENS BEFORE BUYING.
THE BROWN-BIERCE COMPANY.
DAYTON, OHIO.

IF THE BEST IS NOT TOO GOOD FOR YOU
YOU WILL BE SATISFIED WITH
The Telephone Magazine
...FOR 1899...

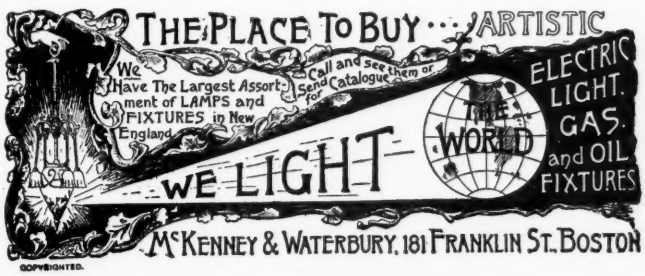
If you are interested in the operation or Construction of **Exchanges, Line Construction, Interior Wiring, Modern Exchange Apparatus, Telephone Troubles** and **How to find them,** or in any other branch of Telephony, send us **A DOLLAR BILL** with your name and address and the Magazine will reach you regularly for a year.

Sample copies free.
Special rates to Agents and Clubs.

Electrical Engineering Publishing Co.
Monadnock Block, CHICAGO.

NEWSDEALERS SELL IT.

Our NEW IMPROVED BATTERY keeps the
American Electric Vehicle Co.
IN THE LEAD — PIONEERS ALWAYS
Send for Catalogue of Carriages
56-58 West Van Buren St. Chicago, U. S. A.


THE PLACE TO BUY ··· ARTISTIC
We Have The Largest Assortment of LAMPS and FIXTURES in New England
Call and see them or Send for Catalogue
ELECTRIC LIGHT, GAS and OIL FIXTURES
WE LIGHT THE WORLD
McKENNEY & WATERBURY, 181 FRANKLIN ST. BOSTON
COPYRIGHTED.

Dixon's Pure Flake Graphite
Is a Blessing to Every Engine Room and Machine Shop.
A small quantity added to any Oil or Grease largely increases its lubricating value and makes the finest Cooling Mixture.
Pamphlet and Sample Sent Free.
JOS. DIXON CRUCIBLE CO., Jersey City, N. J.

Kansas in the Philippines

Is making a reputation for courage and patriotism that stirs our blood.

Kansas in the Cornfields,

Wheatfields and orchards has already made a reputation for gigantic yields that astonishes the world. Oil wells, coal, lead and salt mines furnish a basis for industrial development. Send for free copy of

"What's the Matter

With Kansas?" and for information about homeseekers' excursion tickets via Santa Fe Route

Address General Passenger Office,
The Atchison, Topeka & Santa Fe Railway,
CHICAGO.

"How to Become an Electrical Engineer."

PRICE 25 CENTS.

Paper, Pocket Size.

Prize essays giving practical advice to young men *deciding upon a career.* List of colleges teaching electrical engineering. Address

Electrical Review, Times Bldg., N. Y.

Spanish-American War Panorama and Greater America

is one of the war books which is likely to be in continuous demand. It is a panoramic record of the triumph of Yankee Doodle. The eagle flaps his wings on every page, and "Old Glory" waves around and above every scene. Prominent officers connected with the war are here portrayed, as well as many of the "men behind the guns." Military life is pictured to the eye, from recruiting to guard mount and skirmish line. Nor is the ludicrous omitted. The company cook receives the attention due to his importance; the mess is shown; cavalry scenes are given; the hospital arrangements are depicted; the heroines of the Red Cross service are displayed; street scenes in Havana, Santiago and elsewhere are unrolled; the new citizens or subjects (which are they?) of Uncle Sam appear and disappear as the leaves are turned.

In a word, the gazer visits the new localities and sees the tumultuous new life, without the risk or expense of a sea voyage.

The Album is 5½x8 inches, weighs 12 ounces, printed on finest coated paper.

Mailed to any address in the United States, Canada or Mexico, for 12 cents to cover postage and packing. Copy may be seen at any ticket office of the Big Four Route.

Order at once, as the edition is limited.

Address WARREN J. LYNCH, General Passenger and Ticket Agent, "Big Four Route," Cincinnati, Ohio.

Mark envelope "War Album."

THE ONLY WAY
TO REACH
THE READERS
OF THE

Electrical Review

IS THROUGH THE

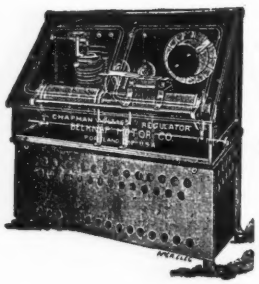
Electrical Review

ITS READERS
ARE WORTH
REACHING, TOO.

A REQUEST TO 41 PARK ROW, NEW YORK, WILL BRING FULL PARTICULARS.

CHAPMAN VOLTAGE REGULATORS

For ALTERNATING or DIRECT CURRENT SYSTEMS.



Insure ***STEADY LIGHTS*** in spite of ***CHANGING SPEED*** and ***VARYING LOADS.*** They ***COMPENSATE*** for ***LINE LOSS*** and automatically keep a constant Voltage at any chosen center of distribution, however distant. Write for particulars.

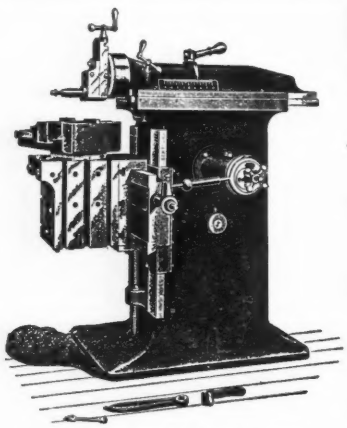
We also manufacture Water Motors, Electric Motors and Dynamos in the Bipolar and Multipolar types. Copper Mills with water and electric attachments.

REGULATORS SENT ON 30 DAYS' TRIAL.

SOLE MANUFACTURERS, **BELKNAP MOTOR COMPANY,**

PORTLAND, - - - MAINE.

Branches: Boston, New York, Philadelphia, Chicago, St. Louis, Milwaukee, Toledo, Denver, San Francisco.



16-inch Adjustable Crank Shaper.

MACHINE TOOLS

OF THE MOST IMPROVED TYPES

MILLING MACHINES
Plain, Universal, Vertical, Lincoln, Double Face, Duplex, Hand.

SCREW MACHINES
With all Combinations of Attachments.

TAPPERS
Plain, Automatic Vertical, Automatic.

Shapers, Drill Presses, Lathes, Profilers, Gear Cutters, Spring Coilers, Forming Machines, Cutter Grinders, Etc. Write for Catalog.

The Garvin Machine Co., SPRING AND VARICK STS., NEW YORK.

PHILADELPHIA: The Garvin Machine Co., 51 North Seventh Street, Philadelphia, Pa.
BERLIN: Deutsche Garvin Machinen Fabrik, Aktienges-llschaft, 17 Burg Strasse, Berlin C. Germany.

STANDARD UNDERGROUND CABLE COMPANY, Westinghouse Bldg., Pittsburgh, Pa. 18 Cortlandt Street, New York. 1225 Betz Building Philadelphia, Pa. 542 The Rookery Chicago, Ill. 507 Security Bldg. St. Louis, Mo.

FIBER PAPER RUBBER **ELECTRIC CABLES,** CEMENT BRICK TILE WOOD **CONDUITS.**

HIGH-GRADE RUBBER COVERED AND WEATHERPROOF **WIRES.** *TELEPHONE, TELEGRAPH, ELECTRIC LIGHT AND POWER.*

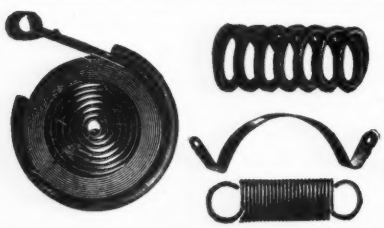
LATHES, PUNCHES AND SHEARS.

Send for Price-List and Catalogue.

W. C. YOUNG MFG. CO.,

Box 1123, WORCESTER, MASS.

Telegraph Address, Young Worcester. Western Union Code Used.



CARY SPRING WORKS,

240 & 242 WEST 29th STREET NEW YORK CITY.

Manufacturers of

WIRE and SPRINGS

For Machinery, Motors, Clocks, Music Boxes, and all kinds of Electrical Purposes.

RUBBER COVERED

WIRES AND CABLES FOR EVERY SERVICE.

For Underground, Aerial and Submarine use, "Safety" wires and cables have the indorsement of some of the largest users in the United States. Write for our booklet containing the experience of users.

THE SAFETY INSULATED WIRE & CABLE CO.,
225 to 239 West 28th Street, New York.

LEONARD F. REQUA, General Manager.

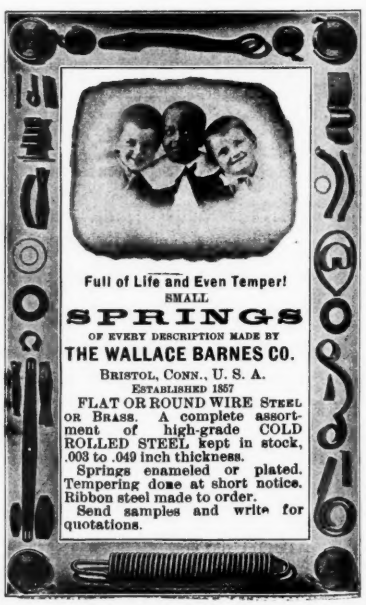
HAIR SPRINGS

For Electric Indicating and Recording Gauges, Steam Gauges, etc.

Non-Magnetic Hair Springs of Phosphor-Bronze and other non-magnetic metals.

Hair Springs of any description manufactured to order.

F. N. MANROSS, Forestville, Conn.



Full of Life and Even Temper!

SMALL

SPRINGS

OF EVERY DESCRIPTION MADE BY

THE WALLACE BARNES CO.

BRISTOL, CONN., U. S. A.

ESTABLISHED 1857

FLAT OR ROUND WIRE STEEL OR BRASS. A complete assortment of high-grade COLD ROLLED STEEL kept in stock, .003 to .049 inch thickness.

Springs enameled or plated. Tempering done at short notice. Ribbon steel made to order.

Send samples and write for quotations.

FOREST CITY ELECTRIC CLEVELAND O. **ROLL DROP** COMMUTATOR BARS HAVE STOOD THE TEST OF TIME

There Is No Higher-class
India-rubber Insulation
For Wires and Cables than

Habirshaw.

Widely Used, Universally Liked,
Specified in Best-grade Installations.

The India Rubber and Gutta Percha Insulating Co.,

Main Office, Glenwood Works,
YONKERS, N. Y.

J. W. GODFREY, Manager Sales,
15 Cortlandt Street, New York.

Sawyer-Man
INCANDESCENT LAMPS

SAWYER-MAN ELECTRIC COMP'Y SYSTEM. TRADE MARK

give better satisfaction than any other lamp on the market.

All principal Supply Houses.

Sawyer-Man Electric Co.,
Allegheny, Pa.

175-c.

BUCKEYE INCANDESCENT LAMPS

QUALITY UNEQUALED.

THE BUCKEYE ELECTRIC CO.,

11 Broadway, NEW YORK. 753 Monadnock Building, CHICAGO. 532 The Bourse, PHILADELPHIA. 524 Tremont Building, BOSTON.

INDEX OF ADVERTISERS.

PAGE

A

Allen & Co., L. B. xvi
Ambor, J. xix
American Battery Co. ....
American Bell Telephone Co. xxi
American Electrical Heater Co. vii
American Electric Telephone Co., long-distance telephones. xxii
American Electric Vehicle Co. xi
American Electrical Works, insulated wire. i
American Endoscopic Co. vi
American Engine Co. vii
American Vitrified Conduit Co. i
Atchison, Topeka & Santa Fe Railway xi

B

Babcock & Wilcox Co. xxiv
Baker & Co., platinum xvi
Ball & Wood Co., engines xix
Barnes Co., The Wallace xii
Barron, Jas. S., & Co. i
Belknap Motor Co. xii
Bibber-White Co viii
"Big Four Route" ....
Billings & Spencer Co i
Boker & Co., Hermann vi
Bossert Electric Construction Co. viii
Brady, T. H. v
Bristol Co. i
Brown-Bierce Co. x
Buckeye Electric Co. xiii
Bullock Electric Manufacturing Co. xvii
Bunnell & Co., J. H., dry batteries iii

C

Cary Spring Works xii
Camp Co., H. B. xvii
Central Electric Co., electrical supplies ii
Central Manufacturing Co. vii
Central Telephone & Electric Co xxiii
Connecticut Telephone and Electric Co. xxi
Crefeld Electrical Works i
Crocker-Wheeler Electric Co. ..... i, ix
Cutler-Hammer Manufacturing Co. ....

D

Diehl Manufacturing Co. ....
Dixon, Jos., Crucible Co., belt dressing. ..... xi, xvi
Duval, E. S., Jr., patents x

E

Eastern Electric Cable Co. ....
Edison Manufacturing Co. xxi
Electric Appliance Company, supplies i
Electric Storage Battery Co. ....
Electrical Engineer Institute of Correspondence Instruction xviii
Electrical Engineering Publishing Co. x
Emerson Electric Manufacturing Co. viii
Empire China Works, porcelain specialties. viii
Ericsson Telephone Co. xvii
Eureka Electric Co. vii

F

Faris & Thayer xvii
Forest City Electric Works xii
For Sale ....
Fort Wayne Electric Works iv
Frink, I. P. ..... vii, xxiv

G

G. & E. Electric Co. viii
Garvin Machine Co. xii
General Electric Co. ii
General Incandescent Arc Light Co. ..... vii, ix
Gordon, A. Y. xxi
Greene, B. E. xvii

H

Hart & Hegeman, electric switches iv
Hart Manufacturing Co. vii

I

Incandescent Electric Light Manipulator Co. x
India Rubber and Gutta Percha Insulating Co xiii
International Correspondence Schools xviii
Ironclad Resistance Co. xviii

J

Jones, J., & Son iii

K

Kartavert Manufacturing Co. xvi
Keystone Electrical Instrument Co. xvi
Klein & Son, Mathias xvii

L

Large & Co viii
Leffel & Co., James v
Lombard Water-Wheel Governor Co. xv

M

Machado & Roller xv
Maintenance Co., The xxiv
Manross, F. N. xii
Marshall, Wm., condensers xxii
McCay Engineering Co. xxiv
McIntire Co., The C. vi
McIntosh, James D. xxiv
McKenney & Waterbury xi
Meserve, F. W. xv
Meyrowitz, E. B. xix
Mianus Electric Co. xxiii
Michigan Electric Co. v
Michigan Pipe Co. xviii
Mona Manufacturing Co. vii
Montauk Multiphase Cable Co. ..... i, viii
Morris, Electric Co. i
Munsell & Co., Eugene xviii

N

National Carbon Co. xvi
National Conduit & Cable Co. i
National India Rubber Co. vii
National Ore & Reduction Co. xvii
New England Butt Co. vi
New England Engineering Co. iii
New York & Ohio Co. vii
New York Insulated Wire Co., Grimshaw wires and cables i
New York Telephone Co. xxii
North Electric Co. xxii
Novelty Electric Co., supplies xvi

O

Ohio Electric Specialty Manufacturing Co.. viii
Ohio Electric Works xix
Okonite Co., insulated wires and cables ..... i, xxiv
Ostrander, W. R., & Co., supplies xix

P

Paiste, H. T., Co. viii
Pelton Engineering Co. xix
Phœnix Battery Manufacturing Co. iv
Phœnix Glass Co. i
Phillips Insulated Wire Co xxiv
Purdue University xvii

R

Reliable Electric Manufacturing Co. ....
Ritchie & Sons vi
Roberts Electric Supply Co. xvii
Roebling's Sons Co., John A. xxiv
Rose Polytechnic Institute xvii

S

Safety Insulated Wire & Cable Co. xii
Samson Cordage Works xxiv
Sawyer-Man Electric Co. xiii
Schiff, Jordan & Co. ....
Shelby Electric Co. i
Siemens & Halske Electric Co. ....
Simplex Electrical Co. i
Sperry, B. N. xviii
Splitdorf, C. F. i
Sprague Electric Co. ....
Standard Paint Co. xvi
Standard Thermometer & Electric Co. v
Standard Underground Cable Co. xii
Stanley & Patterson i
Stewart, Frank H., Co. ..... x, xix
Sterling, C. B., & Co xxi
Sterling Electric Co. xxii
Sterling Supply & Manufacturing Co. iii
Stirling Co., water-tube boilers vi
Stromberg-Carlson Telephone Mfg. Co. xxiii

T

Taber & Mayer xv
The Telephone Manufacturing Co. xxii
Thornberry, Henry S. x

U

United Correspondence Schools xviii
U. S. Mineral Wool Co ....

V

Viaduct Mfg. Co., telephones, etc. xxii

W

Wanted ..... xv, xviii
Ward Leonard Electric Co. xviii
Warren Electric & Specialty Co. i
Webster, Geo. G. xvii
Webster Warren & Co. xvii
Western Electric Co. v
Western Telephone Construction Co. xxiii
Westinghouse Electric & Mfg. Co. xxiii
Williams-Abbott Electric Co. xxi
Williams Electric Co. ....
White & Co., J. G., engineers and contractors xvii
Whitney Electrical Instrument Co. xv
Wyckoff Creosoting Co. xvi

Y

Young, W. C., Mfg. Co. xii

CLASSIFIED LIST.

Alternators.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Batteries, Primary.
Bunnell & Co., J. H.

Batteries, Storage.
American Battery Co.
Electric Storage Battery Co

Battery Material.
Bunnell & Co., J. H.

Bells.
Ostrander & Co., W. R.

Belt Dressing.
Dixon Crucible Co., Joseph

Boilers.
Babcock & Wilcox Co., The
Stirling Co., The

Books, Technical.
Electrical Review Pub. Co

Braiding Machines.
New England Butt Co.

Brokers.
Faris & Thayer.
Greene, B. E.

Brushes, Dynamo.
Crown Woven Wire Brush Co
Goldmark & Wallace.
Hobart Electric Mfg. Co.
Ohio Electric Specialty Mfg. Co

Cable Hangers.
Standard Underground Cable Co

Cabling Machines.
New England Butt Co.

Carbon Points.
General Incandescent Arc Light Co.
National Carbon Co.

Castings.
Billings & Spencer Co.
New England Butt Co.

Circuit-Breakers.
Ward Leonard Electric Co.

Coal Mining Machinery.
General Electric Co.

Commutator Bars and Repairing
Forest City Electric Works.

Commutator Lubricant.
Mona Manufacturing Co.
Ohio Electric Specialty Mfg. Co.

Condensers (Electric).
Marshall, Wm

Conduits.
American Vitrified Conduit Co.
Camp Co., H. B.
Michigan Pipe Co.
National Conduit & Cable Co
Wyckoff Creosoting Co.

Connectors and Terminals.
McIntire Co., The C.

Cord Electric.
Samson Cordage Works.

Contractors.
Webster, Geo. G.

Desk Lamps.
Pacific Electric Co.

Dynamos and Motors.
Bullock Electric Mfg. Co.
Central Electric Co.
Crocker-Wheeler Electric Co.
General Electric Co.
General Incandescent Arc Light Co.
Lincoln Electric Co.
Warren Electric Manufacturing Co.
Westinghouse Electric & Mfg. Co.

Electric Locomotives.
General Electric Co.

Electric Novelties.
Ohio Electric Works.

Electric Heaters.
American Electrical Heater Co.

Electrical Instruments.
Bossert Electric Construction Co.
Central Electric Co.
General Electric Co.
General Incandescent Arc Light Co.
Keystone Electrical Instrument Co.
Whitney Electrical Instrument Co.

Electric Soldering Irons.
American Electrical Heater Co.

Electric Launches.
Sterling & Co., C. B.

Electrical Supplies.
Bibber-White Co.
Bunnell & Co., J. H.
Central Electric Co.
Electric Appliance Co.
Jones, J., & Son.
Novelty Electric Co.
Ohio Electric Works.
Stewart, Frank H., & Co.
Western Electric Co.

Electromobiles.
American Electric Vehicle Co.

Engineers and Contractors.
McCay Engineering Co.
New England Engineering Co.
White & Co., J. G.

Engines.
American Engine Co.
Ball & Wood Co.

Fans and Fan Motors.
Central Electric Co.
Diehl Mfg. Co.
Emerson Electric Mfg. Co.
General Electric Co.
General Incandescent Arc Light Co.
Paragon Fan & Motor Co.
Warren Electric & Specialty Co.

Fiber.
Kartavert Mfg. Co.

Fixtures, Gas and Electric.
McKenney & Waterbury.

Fuse Wire and Links.
General Electric Co.
McIntire Co., The C.

Globes, Shades, Etc.
Frink, I. P.
Phœnix Glass Co.

Graphite.
Dixon Crucible Co., Jos.

House Goods.
Central Electric Co.
Ostrander & Co., W. R.

Instruments (Testing and Recording.)
Bristol Co., The
General Electric Co.
General Incandescent Arc Light Co.
Machado & Roller.
Keystone Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Whitney Electrical Instrument Co.

Insulators and Insulating Material.
Central Electric Co.
Empire China Works.
Kartavert Mfg. Co.
Standard Paint Co.
Standard Underground Cable Co.
Sterling Supply & Mfg. Co.

Junction Boxes.
Bossert Electric Construction Co.
General Incandescent Arc Light Co.
Ward Leonard Electric Co.

Lamps, Arc.
Central Electric Co.
Diehl Mfg. Co.
General Electric Co.
General Incandescent Arc Light Co.
Standard Thermometer & Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

Lamps, Decorative.
Central Electric Co.
Edison Decorative & Miniature Lamp Co.
General Incandescent Arc Light Co.

Lamps, Incandescent.
American Endoscopic Co.
Buckeye Electric Co.
General Electric Co.
General Incandescent Arc Light Co.
New York & Ohio Co.
Ohio Electric Works.
Sawyer-Man Electric Co.
Shelby Electric Co.
Sperry, B. N.
Westinghouse Electric & Mfg. Co.

Lightning Arresters.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Machine Tools.
Garvin Machine Co.

Mast-Arms.
Brady, T. H.
Meserve, F. W.

Meters.
Fort Wayne Electric Works.

Mica.
Munsell, Eugene.

Name-Plates.
Becker-Name Plate Co.

Paint.
Standard Paint Co.

Patent Solicitors.
Duvall, Edw. S.
Thornberry, Henry S.

Platinum.
Baker & Co.

Poles, Brackets, Pins, Etc.
Central Electric Co.
Central Mfg. Co.

Porcelain Manufacturers.
Empire China Works.

Rail Bonds.
Forest City Electric Co.
Morris Electric Co.
Roebling's Sons Co., John A.

Railway Specialties (Electric).
Central Electric Co.
Electric Appliance Company.
General Electric Co.
Novelty Electric Co.
Sterling Supply and Mfg. Co.
Western Electric Co.
Westinghouse Elec. and Mfg. Co.

Reflectors.
Frink, I. P.

Rheostats.
Cutler-Hammer Mfg. Co.
General Incandescent Arc Light Co.
Ohio Electric Specialty Mfg. Co.
Ward Leonard Electric Co.

Schools.
American School of Correspondence.
Electrical Engineer Institute of Correspondence Instruction.
International Corresp. Schools.
United Correspondence Schools.

Soldering Sticks.
Allen & Co., L. B.

Specialties.
G. & E. Electric Co.
General Incandescent Arc Light Co.
Ohio Electric Works.

Steel Spring Wire.
Boker & Co., Hermann.
Cary Spring Works
Manross, F. A.
Wallace Barnes Co.

Storage Batteries.
American Battery Co.
Electric Storage Battery Co.

Switchboards.
Bossert Electric Construction Co.
Central Electric Co.
General Electric Co.
General Incandescent Arc Light Co.
Large & Co.
Western Electric Co.

Switches, Etc.
Central Electric Co.
General Electric Co.
General Incandescent Arc Light Co.

Switches, Etc.
Hart & Hegeman Mfg. Co.
Hart Mfg. Co.
Jones & Son, J.
Paiste Co., H. T.

Telephones.
American Bell Telephone Co.
American Elec. Telephone Co.
Bunnell & Co., J. H.
Central Electric Co.
Central Telephone & Electric Co.
Connecticut Telephone & Electric Co.
Eureka Electric Co.
Gordon, A. Y.
Mianus Electric Co.
Murdock & Co., Wm. J.
National Automatic Telephone Co.
New York Telephone Co.
North Electric Co.
Ohio Electric Works.
Reliable Electric Mfg. Co.
Standard Telephone & Electric Co.
Sterling Electric Co.
Stromberg-Carlson Telegraph Mfg. Co
Taber & Mayer.
Telephone Mfg. Co.
Viaduct Mfg. Co.
Western Electric Co.
Western Telephone Construction Co.
Williams-Abbott Electric Co.
Williams Electric Co.

Tools.
Garvin Machine Co.

Transformers.
Fort Wayne Electric Works.
New York & Ohio Co.
Westinghouse Electric & Mfg. Co.

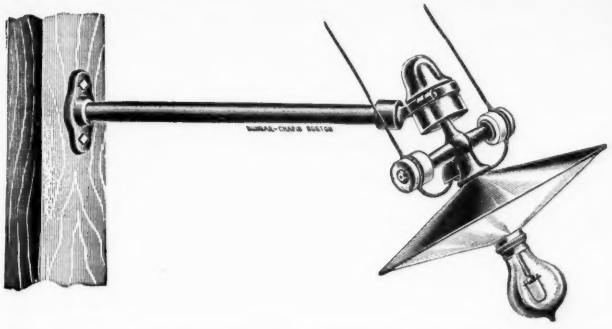
Turbine Governors.
Lombard Water-Wheel Gov. Co.

Voltage Regulators.
Belknap Motor Co.

Water-Wheels.
Leffel & Co., Jas.

Wires and Cables.
American Electrical Works.
Central Electric Co.
Crefeld Electrical Works.
Eastern Electric Cable Co.
Electric Appliance Company.
General Electric Co.
India Rubber & Gutta Percha Insulating Co.
Montauk Multiphase Cable Co.
National Conduit & Cable Co.
National India Rubber Co.
New York Insulated Wire Co.
Novelty Electric Co.
Okonite Co., The.
Phillips Insulated Wire Co.
Roebling's Sons Co., John A.
Safety Insulated Wire & Cable Co.
Simplex Electrical Co.
Standard Underground Cable Co.
Western Electric Co.

X-Ray Apparatus.
Ritchie & Sons.



HIGH-TENSION STREET FIXTURES.

OUR NEW HIGH-TENSION STREET FIXTURE is as perfectly insulated as any part of a circuit, the head being separated from the supporting arm by a double petticoat glass insulator.

NO DANGER of wire being grounded through imperfect insulation as is the case when a fixture depends entirely on a light covering of the wire.

Write us for further description. Manufactured only by

F. W. MESERVE,

Electric Construction and Supplies, South Framingham, Mass.

JUST... ISSUED.

A new catalogue of electrical books has been prepared by the ELECTRICAL REVIEW and is now ready for distribution.

Sent Free on Request...

It is the most complete and satisfactory electrical book catalogue ever prepared.

The Electrical Review

BOOK DEPARTMENT

will send **any electrical book** to **any address** in the world, postage prepaid, on receipt of catalogue price.

Any inquiries addressed to **The Electrical Review Book Department** will receive prompt attention.

Electrical Review Publishing Company,

41 Park Row,

NEW YORK.

HORSELESS CARRIAGE WANTED.

I want to purchase at once A HORSELESS ROAD CARRIAGE, capable of seating four persons. Open or enclosed—will select. Address, stating prices and enclosing illustrations.

Gasoline or Steam Carriage desired.

H. M. HUBBARD,

Care ELECTRICAL REVIEW, New York.

$10. **$10.**

An **Accurate, Permanent Magnet Voltmeter....**

NOT A GAUGE.

MADE IN THE FOLLOWING RANGES:

VOLTMETERS, 0 to 3, 0 to 5, 0 to 10, 0 to 15 Volts.

AMMETERS, 0 to 150 Milamperes, 0 to 500 Milamperes, and 0 to 1000 Milamperes.

WHITNEY ELECTRICAL INST. CO.,

MACHADO & ROLLER,

203 Broadway, New York City,

GENERAL SELLING OFFICE.

CAN WATER-WHEELS BE GOVERNED?

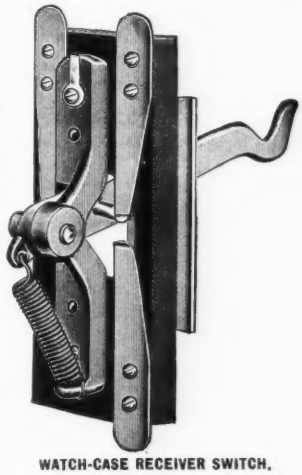
If you will give us a description of your water-wheels and how they are set, we can refer you to a plant similarly arranged, where our governors are in use. Our governors are now being used to regulate over

SEVENTY-FIVE THOUSAND HORSE-POWER

of water-wheels in this country alone. We sell our governors with a POSITIVE GUARANTEE that they will give a better speed regulation than any other make of governor.

LOMBARD WATER-WHEEL GOVERNOR CO.,

61 Hampshire Street (Roxbury District), BOSTON, MASS.



WATCH-CASE RECEIVER SWITCH.

Highest Grade Goods Only.

TABER & MAYER CO.

We are manufacturers, and not only sell complete telephones, but everything pertaining thereto. Our special telephone parts, switches, pushes, transmitters and receivers are in great demand. Be sure and get our prices on these parts, especially our three styles of transmitter.

506 Atlantic Avenue,

BOSTON.

PLATINUM

IN SHEET OR WIRE, ANY SIZE, SHAPE OR DEGREE OF HARDNESS, FOR ALL PURPOSES.

BAKER & CO.,

408-410-412-414 N. J. RAILROAD AVE., NEWARK, N. J.
NEW YORK OFFICE, 120 LIBERTY STREET.
Scrap and Native Platinum Purchased.

THE COLUMBIA DRY CELL...

Is the BEST on earth.

Five Different Sizes.

PARTICULARS, PRICES, AND OUR 70-PAGE CATALOGUE FOR THE ASKING.

National Carbon Co.,

965 Highland Avenue, Cleveland, Ohio.

THE STANDARD

P AND B

ELECTRICAL COMPOUNDS.
ARMATURE AND FIELD-COIL VARNISH.
INSULATING TAPE.
RUBEROID MOTOR CLOTH.

MANUFACTURED BY

The Standard Paint Company,

Chicago Office, 189 Fifth Avenue. 81-83 JOHN STREET, N. Y. Write for Particulars.

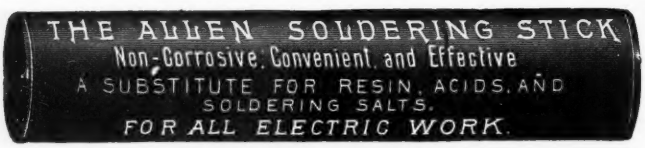
NOVELTY ELECTRIC CO.,

PHILADELPHIA, PA.

Agents for
- Okonite Insulated Wires.
- Medbury Overhead Railway Material.
- Changeable Electric Headlights.
- Globe Metal Works' Trolley Wheels.
- P & B Electrical Compounds.
- Perkins Incandescent Lamps.
- Schiff, Jordan & Co.'s Ship Cored Carbons.

ELECTRICAL SUPPLIES OF EVERY KIND.

If "THE BEST" is your hobby, use


THE ALLEN SOLDERING STICK
Non-Corrosive, Convenient, and Effective
A SUBSTITUTE FOR RESIN, ACIDS, AND SOLDERING SALTS.
FOR ALL ELECTRIC WORK.

MANUFACTURED EXCLUSIVELY BY

L. B. ALLEN CO.,

1335 COLUMBIA AVENUE, CHICAGO, ILL., U. S. A.

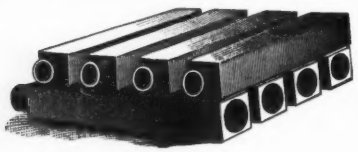
DIXON'S GRAPHITED WOOD GREASE

FOR TROLLEY CAR GEARS.

ABSOLUTELY PREVENTS NOISE AND DOES NOT OOZE OUT OF GEAR CASE.

"LASTS THREE TIMES AS LONG AS ANY OTHER LUBRICANT."

JOS. DIXON CRUCIBLE CO., JERSEY CITY, N. J.



THE WYCKOFF CREOSOTING CO.,

WILLIAMSPORT, PA.

MANUFACTURERS OF

WYCKOFF WOODEN CONDUITS

Also Poles and Cross-Arms.

SWITCHBOARD VOLTMETERS

Ammeters, Ground Detectors and Differential Voltmeters.

Type "K." Illuminated Dial.

We meet all the requirements of modern Central Stations or Isolated Plants, whether using direct or alternating-current circuits.

Our instruments are constant and durable, sensitive and accurate, pleasing in appearance and always correct.

We also manufacture a full line of Portable Instruments. Send for our complete catalogue.

Keystone Electrical Instrument Co.,

Ninth Street and Montgomery Avenue,
PHILADELPHIA.

NEW YORK, 15 Cortlandt Street. CHICAGO, 231 S. Canal Street.

KARTAVERT

FIBER! FIBER! FIBER!

HARD AND FLEXIBLE. IN SHEETS, RODS AND TUBING.

For ELECTRICAL and Mechanical purposes, Railway dust guards, Washers and packings.

MANUFACTURED BY

THE KARTAVERT MANUFACTURING CO., Wilmington, Del.
P. O. BOX 625.